Systematic Review of Strategies to Manage and Allocate Scarce Resources During Mass Casualty Events

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Study objective: Efficient management and allocation of scarce medical resources can improve outcomes for victims of mass casualty events. However, the effectiveness of specific strategies has never been systematically reviewed. We analyze published evidence on strategies to optimize the management and allocation of scarce resources across a wide range of mass casualty event contexts and study designs.

Methods: Our literature search included MEDLINE, Scopus, EMBASE, Cumulative Index to Nursing and Allied Health Literature, Global Health, Web of Science, and the Cochrane Database of Systematic Reviews, from 1990 through late 2011. We also searched the gray literature, using the New York Academy of Medicine's Grey Literature Report and key Web sites. We included both English- and foreign-language articles. We included studies that evaluated strategies used in actual mass casualty events or tested through drills, exercises, or computer simulations. We excluded studies that lacked a comparison group or did not report quantitative outcomes. Data extraction, quality assessment, and strength of evidence ratings were conducted by a single researcher and reviewed by a second; discrepancies were reconciled by the 2 reviewers. Because of heterogeneity in outcome measures, we qualitatively synthesized findings within categories of strategies.

Results: From 5,716 potentially relevant citations, 74 studies met inclusion criteria. Strategies included reducing demand for health care services (18 studies), optimizing use of existing resources (50), augmenting existing resources (5), implementing crisis standards of care (5), and multiple categories (4). The evidence was sufficient to form conclusions on 2 strategies, although the strength of evidence was rated as low. First, as a strategy to reduce demand for health care services, points of dispensing can be used to efficiently distribute biological countermeasures after a bioterrorism attack or influenza pandemic, and their organization influences speed of distribution. Second, as a strategy to optimize use of existing resources, commonly used field triage systems do not perform consistently during actual mass casualty events. The number of high-quality studies addressing other strategies was insufficient to support conclusions about their effectiveness because of differences in study context, comparison groups, and outcome measures. Our literature search may have missed key resource management and allocation strategies because of their extreme heterogeneity. Interrater reliability was not assessed for quality assessments or strength of evidence ratings. Publication bias is likely, given the large number of studies reporting positive findings.

Conclusion: The current evidence base is inadequate to inform providers and policymakers about the most effective strategies for managing or allocating scarce resources during mass casualty events. Consensus on methodological standards that encompass a range of study designs is needed to guide future research and strengthen the evidence base. Evidentiary standards should be developed to promote consensus interpretations of the evidence supporting individual strategies. [Ann Emerg Med. 2013;61:677-689.]

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INTRODUCTION

Mass casualty events generate large numbers of acutely ill or injured people who require immediate medical or mental health care.[1] They may occur suddenly, as is typical of an earthquake, tornado, or bombing,[2] but they may also evolve gradually during hours, days, or even weeks, as is typical of a hurricane, flood, epidemic, or chemical attack.[3]

For the purpose of this review, we define a mass casualty event as one that produces demand for medical care that may outstrip the capacity of local or even regional health care systems to provide conventional standards of care to the affected population.[4] Because mass casualty events typically occur with little or no warning, providers must have contingency plans to meet exceptional demands for care. If these measures prove to be inadequate, providers may need to reallocate resources with a fair, equitable, and transparent process, a concept known as crisis standards of care.[5]

Many strategies have been suggested to optimize management and allocation of scarce resources during a mass

Table 1. Conceptual framework for the review.*

	Resource Management Strategies Under Conventional or Contingency Conditions			
	Manage/Reduce Less Urgent Demand for Health Care Services	**Maximize Use of Existing Resources**	**Augment Resources**	**Implement Strategies Consistent With Crisis Standards of Care**
Policymakers	Implement community-based triage capabilities (eg, telephone-, Web-, or SMS-based triage) Risk communication about when and where to seek treatment Ensure security of health care facilities Communicate triage and treatment guidelines to community-based providers	Provide legal protection for health care providers Provide situational awareness of resource needs and availability Expand scope of practice Relax regulatory obligations	Distribute supplies from stockpiles Exercise mutual aid agreements Request resources from federal government Open alternate care facilities Coordinate and distribute donated resources	Develop and disseminate administrative and clinical guidance about crisis standards of care Disseminate nationally sanctioned activation criteria, clinical algorithms, and other decision support tools
Providers	Cancel elective admissions Triage nonurgent ED visits to off-site settings Use "reverse triage" to identify patients who can be discharged early, treated in a nonhospital setting, or moved to lower-acuity level of care Use remote technologies to support home-based and off-site care	Conserve, reuse, adapt, and substitute resources Transfer patients to less affected hospitals Modify or extend staff shifts Activate stress management programs Reduce recordkeeping requirements Repurpose patient care and nonpatient care areas	Access resources from provider stockpile Request supplemental resources from county, state, or federal governments Request resources from unaffected providers Recruit qualified personnel from outside labor force or unaffected areas	Use pre-established and pre–agreed-on decision tools to allocate critical resources in short supply (eg, based on SOFA score) Implement less than definitive care (eg, "damage control" surgery)

*Source: The authors developed the conceptual framework drawing on reports published by the Institute of Medicine[5] and the Agency for Healthcare Research and Quality.[1]

casualty event, including canceling elective admissions, conserving and reusing resources, accessing resources from stockpiles, and implementing early ICU discharge protocols. These examples illustrate 4 broad categories of strategies that providers and policymakers might use to manage and allocate scarce resources during a mass casualty event: (1) managing or reducing less urgent demand for health care services, (2) optimizing use of existing resources, (3) augmenting existing resources, and (4) implementing crisis standards of care (Table 1).

The effectiveness of implementing specific strategies in each of these areas across a range of meaningful outcomes, particularly patients' health, has not been systematically assessed, to our knowledge. To help policymakers and providers identity the best options, the Office of the Assistant Secretary for Preparedness and Response, US Department of Health and Human Services, formally requested that the Agency for Healthcare Research and Quality commission a systematic review of the evidence on the effectiveness of resource management and allocation strategies across a wide range of mass casualty event contexts.

MATERIALS AND METHODS

This evidence review was guided by a 2009 article issued by the Institute of Medicine describing adaptive strategies for surge conditions arising from mass casualty events.[5] We organized our work around the 4 broad categories of strategies mentioned above—a framework that accommodated the majority of strategies that were referenced in the Institute of Medicine article. We sought to identify the best available evidence within each broad category. The full article with additional details on our methodology can be found elsewhere.[6] The 27-item PRISMA Checklist guided the structure and the content of this report (Appendix E1, available online at http://www.annemergmed.com).[7]

To identify relevant studies, we searched 7 research databases, including PubMed, Scopus, EMBASE, Cumulative Index to Nursing and Allied Health Literature, Global Health, Web of Science, and the Cochrane Database of Systematic Reviews, from 1990 through November 2011. To identify relevant books, we searched the National Library of Medicine's online catalog. We supplemented these searches with a scan of the gray literature, using the New York Academy of Medicine's Grey Literature Report and Web sites of government agencies, provider organizations, and academic research centers. Appendix E2 (available online at http://www.annemergmed.com) contains a list of the literature search terms.

We considered both US and international sources, including non–English-language articles that met our 2 primary inclusion criteria. First, eligible studies had to prospectively assess a strategy during an actual event, document its effect in an after-action report, or test its effectiveness in an exercise, drill, or computer simulation.

Second, to ensure that studies met a minimum threshold of scientific rigor, they had to have compared an intervention with 1 or more alternative interventions, use a control group, or use some other objective benchmark. Given the anticipated diversity of strategies, we considered a broad set of outcome measures, including health, cost, ethical, and legal outcomes, as well as process measures, such as triage accuracy rate and triage time. Because studies inconsistently reported the issuance of disaster declarations and often failed to fully characterize the extent of resource shortages, our review included both mass casualty events and quite likely some events that produced conditions of excessive surge that would not be classified as mass casualty events. Appendix E3 (available online at http://www.annemergmed.com) contains a list of excluded studies and the reasons for exclusion.

Data Collection and Processing

Two researchers (AK, JR) screened all titles. Abstracts and full-text articles underwent dual review. We resolved disagreement by consensus or, when necessary, third-party reconciliation. Data were abstracted with the DistillerSR program. Core data elements included study design, geographic location, type of mass casualty event, description of the strategy, outcomes, and facilitators or barriers to the implementation of each strategy.

After finding no suitable quality assessment tools in the peer-reviewed literature, we developed a 5-item scale that enabled comparisons of methodological quality across diverse types of studies. We combined key domains from 3 sources. From the National Registry of Evidence-based Programs and Practices[8] quality assessment scale from the Substance Abuse and Mental Health Services Administration we used 2 items: (1) whether the strategy was implemented with fidelity (ie, implemented consistently), and (2) whether the authors discussed potential confounders to the strategy's effectiveness. The remaining 3 items represent core elements of 2 common frameworks frequently used to appraise the quality of qualitative research: those by Mays and Pope[9] and Lincoln and Guba.[10] These 3 items assessed whether the level of detail used to describe the resource allocation strategy was adequate, whether data collection was systematic (and if so, whether it was retrospective or prospective), and whether the authors assessed the generalizability of findings. Two reviewers reconciled all differences in scores for each quality item. For computer simulations, we included 2 items that assessed justification of model inputs and the robustness of sensitivity analyses (and eliminated the data collection item and implementation fidelity item). For systematic reviews, we used the 11-item AMSTAR instrument.[11]

Primary Data Analysis

Because of the breadth of topics we reviewed, we conducted systematic reviews within subcategories of resource management and allocation strategies. We combined these results into a single report because our conclusions were largely similar across most categories. The data were not amenable to quantitative synthesis because abstracted studies rarely addressed similar strategies. Moreover, when multiple studies did assess a common strategy, they typically differed widely in their settings, comparison groups, and outcome measures. Accordingly, we summarized the results qualitatively, using the 4 broad categories from the conceptual framework shown in Table 1 and subcategories when clusters of related strategies emerged. Wherever possible, we summarized the degree of consistency in the magnitude and direction of the most relevant outcomes. We also highlighted contextual and methodological differences that were relevant to the interpretation of results.

We graded the strength of evidence by using the methodology commonly used for systematic reviews commissioned by the Agency for Healthcare Research and Quality.[12] It requires reviewers to consider 4 key domains—risk of bias, consistency, directness, and precision—and then grade the overall strength of the evidence, using a 4-point scale (ie, high, moderate, low, or insufficient). Grades were assigned by one reviewer and confirmed by a second, followed by discussion when conflicts arose. We rated the strength of evidence within the 4 domains for individual categories (or subcategories) of resource management and allocation strategies, depending on the number of studies available. A single reviewer graded the strength of evidence for each domain within categories of strategies and overall. The ratings were then reviewed by a second researcher and differences were reconciled through discussion.

RESULTS

Our search strategy identified 5,716 potentially relevant citations. After applying exclusion criteria, only 74 articles underwent data extraction (Figure). These 74 studies comprised 3 main types of analyses: 48 were intervention studies (ie, involving human subjects), including 23 that evaluated the outcomes of drills and 25 that reported findings from actual mass casualty events (Table 2). Nearly half of the intervention studies (25 of 48) occurred in the United States. The other 23 took place elsewhere, particularly Europe (8) and Israel (6). The remaining 26 nonintervention studies included computer simulations (17), systematic reviews (2), validation analyses (5), and laboratory studies (2).

Twenty-three studies focused on biological threats, including pandemic influenza (13), anthrax (7), smallpox (2), and SARS (1). Nine studies addressed natural disasters, including 6 earthquakes (3 of which involved Hurricane Katrina). Ten reported outcomes after a terrorist attack with explosives. The remaining mass casualty events included nuclear/radiologic events (3), transportation accidents (3), chemical events (3),

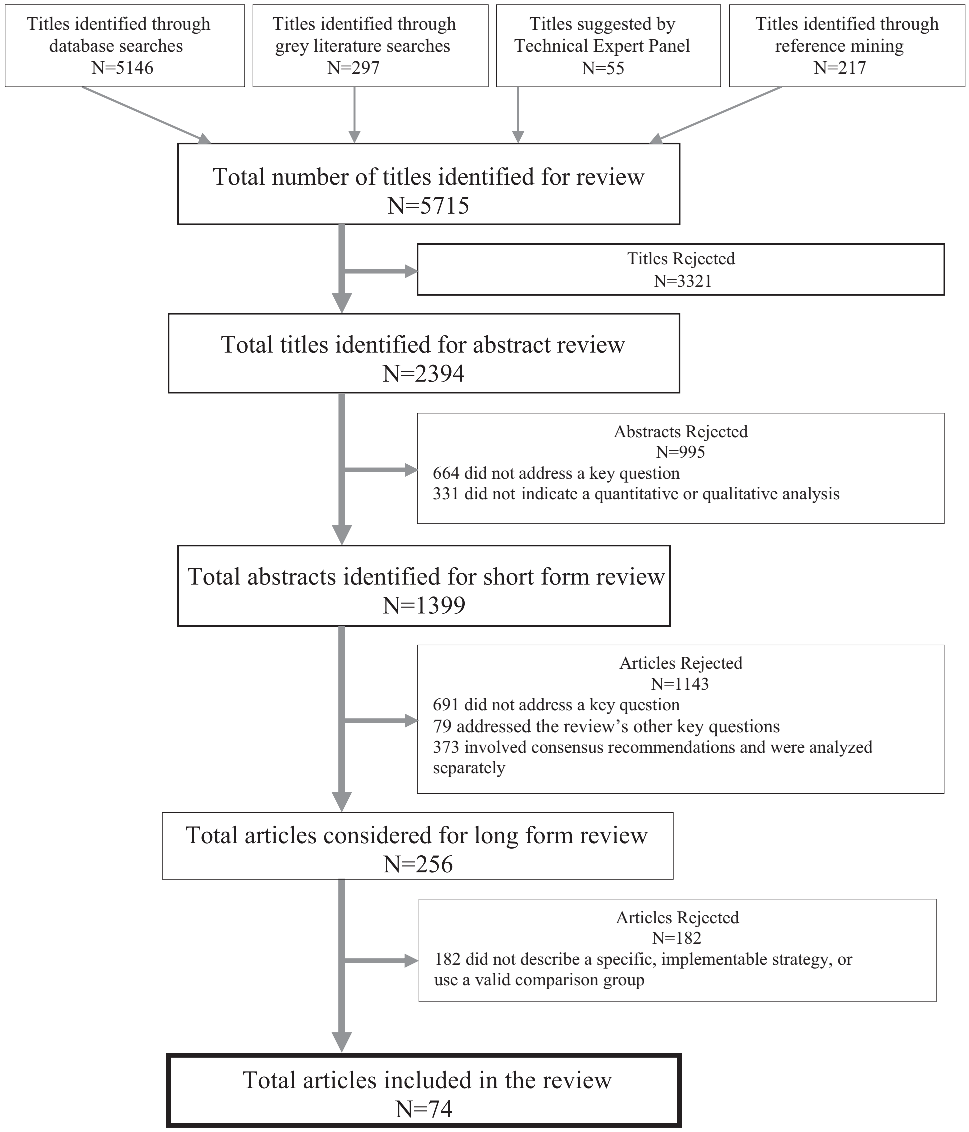

Figure. Literature flow.

multiple hazards (10), unspecified events (10), and other types of mass casualty events (5).

Table 3 groups the studies according to the 4 broad categories of resource allocation strategies defined in our conceptual framework. In the sections that follow, we discuss only the studies relevant to distribution of "biological countermeasures" and "field triage," the 2 subcategories for which the evidence was sufficient to form tentative conclusions about their effectiveness. We also summarize the available evidence on implementation of crisis standards of care—an area of particular interest to providers and policymakers. Appendix E4 (available online at http://www.annemergmed.com) contains detailed descriptions of each study.

Among the 18 studies that addressed strategies to reduce or manage demand for health care services, 5 examined the utility of points of dispensing to speed distribution of biological countermeasures. Three of the 5 studies used exercises to assess techniques for rapidly distributing medical countermeasures against anthrax. The first of these, an exercise conducted in Nassau County, NY, demonstrated that a traditional "centralized" point-of-dispensing system provided slightly faster throughput than a hybrid model. In the centralized point-of-dispensing model, individuals came to a fixed site to receive a medical countermeasure (a "pull" approach), whereas in the hybrid model, the pull approach was combined with a "push" strategy in which countermeasures were distributed to individuals at their work site.[13]

The second study compared a pull model to a different type of push model—one that used US Postal Service mail carriers to deliver countermeasures to people's homes.[14] It found that using mail carriers served more people per hour per provider than did operating a fixed dispensing site. Although these 2

Table 2. Characteristics of studies included in the review.

Characteristics	Number of Studies (Percentage of All Studies)
All studies	74 (100)
Study type	
Intervention studies*	48 (65)
Drills	23 (48)
Actual MCEs	25 (52)
Computer simulations	17 (23)
Systematic reviews	2 (3)
Validation analyses	5 (7)
Laboratory analyses	2 (3)
Study setting†	
United States	25 (52)
Europe	8 (17)
Israel	6 (13)
Asia	3 (6)
Canada	2 (4)
Australia	1 (2)
Mexico	1 (2)
Rwanda	1 (2)
Haiti	1 (2)
Type of event	
Pandemic influenza	13 (18)
Explosive	10 (14)
Multiple hazards	10 (14)
Anthrax	7 (9)
Natural disasters: earthquake	6 (8)
Natural disasters: hurricane	3 (4)
Nuclear/radiologic events	3 (4)
Transportation accidents	3 (4)
Chemical events	3 (4)
Smallpox	2 (3)
SARS	1 (1)
Other	3 (4)
Unspecified events	10 (14)

MCE, Mass casualty event.
*We use the term "intervention study" to refer to any study that tested a strategy with human subjects and includes both drills and actual MCE.
†Among intervention studies only.

studies provide only limited evidence, both were relatively large-scale, high-quality exercises that were conducted in different geographic regions. Therefore, we judged them as providing highly applicable evidence.

The third study, a multicounty exercise in metropolitan Atlanta, documented that point-of-dispensing operations supported by a particular decision-support software tool were more efficient than traditional dispensing systems. However, the majority of findings from this study were qualitative and therefore not comparable to the other results in this category.[15] This same software tool was used to simulate different patient arrival patterns in another study of the effectiveness of points of dispensing that concluded that a dynamic staffing model significantly reduces waiting times for individuals seeking countermeasures.[16]

The only point-of-dispensing study conducted during an actual mass casualty event involved countermeasure distribution during a hepatitis A outbreak in eastern Tennessee. In this study, the community implemented a mass vaccination protocol originally developed by the Centers for Disease Control and Prevention for anthrax and achieved benchmark levels of throughput.[17]

Although 2 exercise-based studies that compared different point-of-dispensing systems were judged to provide high-quality evidence, neither tested the approach during an actual event. Furthermore, only 2 of the 5 studies in this category were comparable, representing a very limited evidence base. Accordingly, the overall strength of evidence about the optimal approach to distributing biological countermeasures was rated as low.

Among the 50 studies that evaluated strategies intended to optimize use of existing resources during a mass casualty event, fully half focused on out-of-hospital (also known as "field") triage systems. Thirteen studies assessed the performance of responders who used these triage systems during a drill or an actual mass casualty event, whereas 9 sought to validate new or existing triage systems through other design (eg, medical record review). The other 3 examined issues related to triage but were determined to be noncomparable. We concluded that the strength of evidence to favor use of any particular field triage system over others was low.

Thirteen studies of field triage systems examined their performance during actual (6) or simulated mass casualty events (7). Few of the triage tools assessed in these tests applied to pediatric victims, and only 2 studies addressed chemical, biological, radiologic, or nuclear mass casualty events.[18,19] Most focused on adult populations involving victims of trauma and thus used quite similar triage protocols.

The reported accuracy of these systems ranged from 62% to 100% across the 10 studies that included this information (Table 4). Studies reporting results from actual mass casualty events (2 terrorist bombing events, including the London Transit bombings) suggest that overtriage rates may range from 33% to 64%. In another study, the use of "reverse" triage among patients with low scores on an influenza-like illness scale successfully increased surge capacity in a Mexican emergency department (ED) during the 2009 H1N1 pandemic.[20]

The 7 studies that used drills to evaluate triage systems reported higher rates of accuracy than studies examining the performance of these systems in actual mass casualty events. Two systems associated with higher levels of performance examined triage during chemical, biological, radiologic, or nuclear events[18] or radiologic events alone.[19] However, only 1 of these systems was developed with data from patients experiencing acute radiation syndrome; the other was based on expert opinion. Four studies, including 2 that evaluated the accuracy of the triage system sort, assess, lifesaving interventions, treatment/support, were immediately preceded by a formal training program, so it is unlikely that their results will accurately predict the performance of each system during an actual mass casualty event.

Table 3. Resource allocation strategies included in the systematic review.*

Author	Study Type	MCE Type	Description of Strategies	Quality Score	Summary
Strategies to reduce or manage less urgent demand for health care services					
Allocation of biological countermeasures					
Arora, 2010[39]	Computer sim	Influenza	Optimize level of preallocation of antiviral stockpile and percentage allocated for prophylaxis and treatment for influenza	4/7	Noncomparable strategies Three different biological threats studied
McCaw, 2008[40]	Computer sim	Influenza	Optimize the use of multiple drugs for prophylaxis or treatment	7/9	All studies were computer simulations
Wein, 2003[41]	Computer sim	Anthrax	Implement prioritization policies, implement biosensor deployment, or deploy federal or military resources and volunteers	5/9	Insufficient evidence
Bravata, 2006[42]	Computer sim	Anthrax	Increase local stockpiles, deploy stockpile to targeted areas, enhance detection, or increase dispensing capacity	7/9	
Zaric, 2008[43]	Computer sim	Anthrax		3/9	
Glasser, 2010[44]	Computer sim	Influenza	Targeting vaccination to different populations	2/7	
McVernon, 2010[45]	Computer sim	Influenza		4/7	
Medlock, 2009[46]	Computer sim	Influenza		5/9	
Zenihana, 2010[47]	Computer sim	Smallpox	Mass vaccination, contact tracing, and school closure	3/7	
Distribution of biological countermeasures					
Ablah, 2010[13]	Exercise	Anthrax	Centralized POD system vs hybrid (pull and push approach)	6/8	Mail carrier strategy may dominate centralized model
Koh, 2008[14]	Exercise	Anthrax	Centralized POD system vs push model using US Postal Service mail carriers	6/8	Three large-scale exercises Low strength of evidence
Lee, 2006[15]	Exercise	Anthrax	POD operations supported by a decision-support software tool	4/8	
Hupert, 2009[16]	Computer sim	Anthrax	Use of dynamic staffing during POD implementation	2/7	
Erwin, 2009[17]	Actual MCE	Smallpox	Implementation of Centers for Disease Control and Prevention mass vaccination protocol	4/8	
Nonbiological countermeasures					
Cahill, 2008[48]	Computer sim	Influenza	Distribution of surgical masks or N95 respirators to the public	2/9	Each study evaluated a distinct strategy
Schull, 2007[49]	Actual MCE	SARS	Restrict nonurgent demand for hospital care	4/8	Insufficient evidence
Savoia, 2009[50]	Exercise	Influenza	Training public health officials in their legal authority to implement strategies to limit the spread of pandemics	4/7	
Adini, 2010[51]	Actual MCE	All hazards	Automated central information distribution system for families	4/8	
Strategies to optimize use of existing resources					
Field triage studies: implementation tests					
Cohen, 1998[52]	Actual MCE	Explosive	American College of Surgeons Committee on Trauma criteria	4/8	Few triage systems tested during real events
Cone, 2008[18]	Exercise	Chemical	Combined trauma/CBRN-specific system	6/8	Studies assessed different outcomes
Rodriguez-Noriega, 2010[20]	Actual MCE	Influenza	Influenza-Like Illness Scoring System	5/8	Few studies tested in real MCEs assessed mortality
Aylwin, 2006[31]	Actual MCE	Explosive	London Transit bombings protocol	5/8	Low strength of evidence
Kuniak, 2008[19]	Exercise	Radiologic	Radiation Injury Severity Classification	6/8	
Cone, 2009[53]	Exercise	All hazards	SALT protocol	5/8	
Lerner, 2010[54]	Exercise	Explosive		5/8	
Zoraster, 2007[21]	Actual MCE	Transportation accident	START	4/6	
Schenker, 2006[22]	Exercise	Multiple		6/8	
Gutsch, 2006[55]	Exercise	Unspecified	Modified START triage algorithm (mSTART)	4/4	
Rehn, 2010[56]	Exercise	Transportation accident	Interdisciplinary Emergency Service Cooperation Course (TAS Triage Method)	6/8	

Table 3. Continued.

Author	Study Type	MCE Type	Description of Strategies	Quality Score	Summary
Cryer, 2010[57]	Actual MCE	Transportation accident	Los Angeles Commuter Rail accident	5/8	
Janousek, 1999[58]	Exercise	Multiple	NATO triage classification system	3/7	
Field triage studies: derivation/validation studies					
Adeniji, 2011[59]	Validation	Influenza	Simple Triage Scoring System (STSS)	3/6	
Casagrande, 2011[60]	Computer sim	Nuclear	Model of Resource and Time-based Triage	6/9	
Cancio, 2008[61]	Validation	Combat	Field Triage Score vs Revised Trauma Score	4/6	
Guest, 2009[62]	Validation	Influenza	Christian et al triage protocol	5/7	
Navin, 2009[25]	Computer sim	Unspecified	Sacco Triage Method	3/7	
Sacco, 2007[27]	Computer sim	Unspecified		5/7	
Nie, 2010[63]	Actual MCE	Earthquake	Modified START (includes resuscitation category)	2/8	
Beyersdorf, 1996[64]	Actual MCE	Mass shooting	Revised Trauma Score vs Pre-hospital Index vs Washington state Pre-hospital Trauma Triage Procedure	2/6	
Kilner, 2010[23]	Sys review	Multiple	Systematic review of triage systems	8/8	
Field triage studies: other					
Hirshberg, 2010[65]	Computer sim	Explosive	Role assignment during 2-stage triage system	6/9	
Romm, 2011[66]	Laboratory test	Radio/nucl	Expedited biodosimetry method	5/5	
Gao, 2007[67]	Exercise	Unspecified	Electronic triage tags to monitor vital signs and transmit information to first responders	5/8	
Load-sharing					
Kanter, 2007[28]	Computer sim	Unspecified	Existing regional systems to optimize allocation of patients to hospitals	3/9	Israeli home command system may not be generalizable to United States Three studies provide low-applicability evidence Insufficient evidence
Epley, 2006[68]	Actual MCE	Hurricane		4/8	
Leiba, 2006[69]	Actual MCE	Explosive		2/8	
Raiter, 2008[70]	Actual MCE	Explosive		3/8	
Xiong, 2010[71]	Computer sim	Earthquake		2/7	
Simon, 2001[72]	Actual MCE	Explosive	Ad hoc incident command structures to optimize allocation of patients to hospitals	2/8	
Wolf, 2009[73]	Exercise	Unspecified	Load-sharing protocol for mass gatherings	8/8	
Imaging					
Beck-Razi, 2007[74]	Actual MCE	Explosive	Focused assessment of sonography for trauma (FAST) for triage	6/8	Sonogram studies used distinct criterion standards CT protocols tested in exercises only Insufficient evidence
Sarkisian, 1991[75]	Actual MCE	Earthquake		4/8	
Korner, 2006[76]	Exercise	Unspecified	Accelerated CT protocols	5/7	
Korner, 2011[77]	Exercise	Unspecified		7/8	
Medical interventions					
Gunal, 2004[78]	Actual MCE	Earthquake	Medical interventions for the prevention of acute renal failure in crush victims	6/8	Studies addressed different topics Insufficient evidence
Vardi, 2004[79]	Exercise	Chemical	Novel drug infusion devices	6/8	
Space optimization					
Satterthwaite, 2010[80]	Actual MCE	Explos/trans accident	Reverse triage to create surge capacity	2/7	Only 1 of the 2 reverse triage protocols was truly tested Insufficient evidence
Van Cleve, 2011[81]	Actual MCE	Influenza		5/8	
Scarfone, 2011[82]	Actual MCE	Influenza	Conversion of lobbies, clinics, and other units to accommodate surge	2/8	

Table 3. Continued.

Author	Study Type	MCE Type	Description of Strategies	Quality Score	Summary
Training					
Hsu, 2004[83]	Sys Review	Multiple	MCE response training (including drills, tabletop exercises, computer simulations)	7/10	Systematic review suggests drills are effective
Jarvis, 2009[84]	Exercise	Unspecified	Game-based training	4/8	Most studies reported lessons learned
Andreatta, 2010[85]	Exercise	Explosive	Virtual reality training	6/6	Longer-term effectiveness of training is unknown
Vincent, 2008[86]	Exercise	Unspecified		4/7	
Vincent, 2009[87]	Exercise	Explosive	Podcasts and multimanikin simulations	3/5	Insufficient evidence
Sanddal, 2004[88]	Exercise	Explos/trans accident	"JumpSTART" training session followed by drill	6/8	
Other					
Einav, 2009[89]	Actual MCE	Explosive	Hospital-based case managers to ensure care coordination	3/8	Studies addressed different topics Insufficient evidence
Amlot, 2010[90]	Exercise	CBRN	Multiple strategies to increase decontamination effectiveness	3/6	
Loeb, 2009[37]	Actual MCE	Influenza	Influenza prophylaxis for health care workers: surgical masks vs N95 respirators	5/6	
Strategies to augment existing resources					
Temporary facilities					
Eastman, 2007[91]	Actual MCE	Hurricane	Alternate-site surge capacity facilities	4/7	Three studies assessing temporary facilities shared same context: hurricane
Blackwell, 2007[92]	Actual MCE	Hurricane	Deployment of mobile field hospital	3/5	Potentially limited generalizability to other MCEs
Wein, 2003[41]	Computer sim	Anthrax	Activating mobile provider units from other federal agencies to provide hospital surge capacity	5/9	Insufficient evidence
Other					
Arora, 2010[39]	Computer sim	Influenza	Mutual aid agreements for the transfer of antivirals between counties	4/7	
Corvino, 2006[93]	Laboratory	Chemical	Conversion between formulations of nerve agents to augment supply	6/7	
Strategies for implementing crisis standards of care					
Damage-control surgery/care					
Dhar, 2008[29]	Actual MCE	Earthquake	External fixation of fractures rather than definitive orthopedic care	5/8	Contexts include terrorist bombing, earthquake, civil war, and unspecified
Labeeu, 1996[30]	Actual MCE	Combat		1/6	
Aylwin, 2006[31]	Actual MCE	Explosive	Limited advanced on-scene interventions, delaying nonurgent CT scans, limited use of blood typing and cross-matching	5/8	Limited measurement of patient outcomes
Other					Insufficient evidence
Merin, 2010[32]	Actual MCE	Earthquake	Very early discharge from ICU	1/6	
Kanter, 2007[28]	Computer sim	Unspecified	Essential interventions (unspecified) for pediatric MCE victims	3/9	

sim, Simulation; *POD*, point of dispensing; *CBRN*, chemical/biological/radiologic/nuclear; *SALT*, sort, assess, lifesaving interventions, treatment/support; *SMART*, Simple Triage and Rapid Treatment; *TAS*, Interdisciplinary Emergency Service Cooperation Course.
*The numerator of the quality score reflects the number of points achieved. The denominator reflects the total number of points for the applicable items.

The methodological shortcomings of drills may help to explain why several studies have found that field triage systems often face challenges when implemented in practice. For example, in a commuter rail incident, use of another well-known field triage tool, simple triage and rapid treatment (START), resulted in misallocation of patients between trauma centers and community hospitals because of provider confusion about the meaning of each triage category.[21] In addition, one exercise found that the START triage system is not sensitive to serious nontrauma conditions, such as a myocardial infarction or an asthma attack, and may therefore undertriage victims with these conditions.[22]

Nine studies reported data from validation analyses but did not formally test 1 or more triage systems. One study was a systematic review comprising 11 articles on 8 triage systems.[23] Only 1 of the 11 studies used data collected from an actual mass casualty event in which START was used to triage patients of a transportation incident and resulted in an overtriage rate of 53%.[24] The authors concluded that there is little evidence to favor one system over the others because of small sample sizes and low methodological quality of the studies, but the Sacco Triage Method[25-27] was described as "promising" because it takes the available capacity at receiving hospitals into consideration.

Table 4. Accuracy of triage for individual triage tools reported in 10 included studies.*

Triage System	Study Design	Undertriage Rate, %	Overtriage Rate, %	Overall Triage Accuracy, %
ACS Committee on Trauma criteria[52]	MCE	1[†]	33	—
Influenza-like Illness Scoring system[20]	MCE	<1	—	—
London Transit bombings triage method[31]	MCE	—	64	—
CBRN triage system[18]	Drill	11	2	—
Radiation Injury Severity Classification[19]	Drill	—	—	95
SALT[54]	Drill	10	6	83
SALT[53]	Drill	4	13	79
START[22]	Drill	—	—	70
START[22]	Drill	—	—	62[‡]
mSTART[55]	Drill	3	5	—
TAS Triage method[56]	Drill	0	0	100

ACS, American College of Surgeons; *mSTART*, modified Simple Triage and Rapid Treatment; —, not reported.
*Data from 3 systems were not amenable to synthesis,[21,57,58] 4 studies included previous training,[18,53,54,56] and 1 included the use of aids that may have influenced triage accuracy rates.[53]
†Rates for moderately injured patients are reported. Undertriage rate for critical patients was 1% and for severely injured patients was 14%.
‡Accuracy of triage when clinical status was manipulated for 47 patients.

Adding 8 additional validation studies of triage systems did not change the overall conclusion from the previous systematic review. Because the majority of these studies did not include evidence on how these triage systems performed under real or realistically simulated conditions, we judged the collection of studies to have very limited applicability. For example, the Sacco Triage Method requires relatively advanced health information technology and a reliable communication system to develop and transmit triage instructions to providers. The feasibility of implementing such a system in a mass casualty event is unclear.

Five studies evaluated resource allocation strategies that might be implemented under crisis standards of care. Three examined “damage control surgery,” an approach to initial surgical treatment that strictly focuses on initial stabilization, with definitive repair deferred. The fourth study examined the usefulness of modified ICU admission and discharge policies. The fifth and final study in this subcategory used computer simulation to model the potential effect of restricting care to only “essential interventions” but did not specify them.[28]

Two of the damage control surgery studies focused on orthopedic surgery, whereas the third examined trauma surgery more broadly. The first study reported that hospitals implementing “damage control” orthopedic surgery in the aftermath of an earthquake in Kashmir in 2008 expanded operating room capacity by 37%, with minimal effect on patient outcomes 1 year after the earthquake.[29] The second found that under battlefield conditions, early use of external fixation improves throughput but at the cost of a higher rate of complications, particularly surgical infections.[30] The third study observed that use of damage control surgery boosted surge capacity in the hospitals that received a sudden influx of complex trauma victims from the 2005 London Transit bombings.[31]

The study that focused on ICU admission and discharge policies described the experience of the Israeli Defense Force field hospital, which cared for numerous victims of the 2010 Haiti earthquake.[32] Faced with extraordinary demand, the hospital prioritized its ICU beds for patients who could be stabilized within 24 hours and adopted a policy of accelerated discharge from intensive care. Although the authors concluded that these policies enabled them to treat a substantially larger number of victims than would otherwise have been possible, they did not systematically assess how the policies affected patient outcomes.

LIMITATIONS

To accommodate the vast and heterogeneous body of literature on this topic, we were obliged to make several methodological tradeoffs. First, because the objective of our study was to conduct the first systematic review on the most effective resource management and allocation strategies during mass casualty events, we were unable to specify more precise research questions. For example, although we might have included only those studies that used a narrow set of outcome measures, such as survival, we erred on the side of being more inclusive.

Second, because we were asked to identify resource allocation strategies across the full spectrum of preparedness and response options, we used a broad set of search terms to scan the literature. It is possible that our approach did not identify every important strategy or every key study for the strategies included in the review because they were not specified as formal search terms.

Third, in recognition that the evidence was likely to be sparse in many areas, we elected not to use exclusion criteria relating to study type. As a result, 2 existing systematic reviews were included in the review.

Fourth, to accommodate a broad range of study types, we developed a quality assessment scale. Although we did not calculate the interrater reliability of quality scores, the incidence of discrepant scores that required reconciliation between reviewers was frequent enough to suggest that the scale could be further refined. The scale should also undergo validity testing.

Fifth, although the scope of our review was broad, it did not address every aspect of the management of mass casualty events, such as detailed clinical treatment and the technical considerations involved in interfacility transport of critically ill and injured patients.

Sixth, although we did not conduct a formal assessment of publication bias, the majority of studies we found reported positive findings, suggesting that publication bias may be a factor.

DISCUSSION

In 2009, the Institute of Medicine Committee on Guidance for Establishing Standards of Care for Use in Disaster Situations published a Letter Report recommending that health care providers, organizations, government officials, and the public approach the challenge of allocating scarce resources in a thoughtful and proactive way.[5] Building on that report, the Institute of Medicine recently described the core functions of stakeholders engaged in preparedness and response to mass casualty events and enumerated specific tasks to help ensure that each stakeholder successfully fulfill these core functions.[33] To complement the Institute of Medicine's work, we undertook this systematic review to compile, for the first time, to our knowledge, the best available evidence on strategies to manage and allocate scarce medical resources during mass casualty events. Our hope was that the resulting evidence base might be sufficient to improve existing disaster response plans and more closely align them within the Institute of Medicine's disaster response framework.[5,33]

The need for better evidence is clear. It is only a matter of time before the United States will experience another natural or man-made disaster, a pandemic, or a terrorist attack that outstrips the capacity of our health care system to respond. When it occurs, health care workers and the policymakers who support them will be forced to make difficult decisions under highly demanding and generally quite public circumstances. Because resource allocation decisions are fraught with clinical, legal, and ethical implications, they should be grounded in rigorous evidence.

Unfortunately, our review found limited evidence to help providers and policymakers make such decisions. Within all but a few categories, individual strategies were evaluated by no more than 3 studies. Most of the studies we reviewed were prone to at least a moderate level of bias, and many had serious methodological flaws. Most relied on process measures (such as patient throughput) to assess their effectiveness rather than the intervention's effect on patient health. The few that did report outcomes generally did so during a very short timeframe. Only one third of the studies that met our generous inclusion criteria used data from actual mass casualty events, which is problematic because simulations and drills may not adequately replicate the physical conditions and emotional stress of responding to an actual disaster. In all but 2 areas, the evidence was insufficient to draw conclusions about the effectiveness of specific resource management or allocation strategies.

By their nature, mass casualty events are both uncommon and unpredictable. Conducting health services research in such a context presents extraordinary challenges. The rarity of mass casualty events necessitates use of study designs such as computer simulations, drills, and quasi-experimental studies involving actual mass casualty events, all of which are commonly regarded as producing inferior evidence to prospective, randomized trials. Computer simulations and staged drills can accommodate the design features of experiments such as prospective recruitment of participants and random allocation of strategies, but they raise significant concerns about fidelity and validity. Consensus is urgently needed to establish acceptable methodological and evidentiary standards for future research in disaster preparedness and response, particularly about studies that use drills, computer simulations, and prospective evaluation of strategies implemented during an actual mass casualty event. For example, experts might consider process measures sufficient to evaluate a field triage system, but outcome measures should be collected to assess the effect of an accelerated discharge policy.

Given the practical and ethical challenges of conducting prospective studies during mass casualty events, federal agencies should proactively work with experts in the field to create "research preparedness," the capacity to rapidly generate useful empirical observations and conduct urgently needed studies during unfolding mass casualty events.[34] Useful steps might include a standardized, "Utstein style" approach to documenting essential information about the immediate medical response to disasters and large-scale acts of terrorism[35]; a more standardized approach to the selection of comparison groups; a thoughtful approach to the ethics of disaster research, including the potential for preapproved protocols sanctioned by national institutional review boards[36]; and contingent grant awards to provide the necessary funding required to immediately deploy a research team to a future mass casualty event. Such innovations could quickly build a reasonably rigorous evidence base to inform policy and practice.

Even if a research infrastructure can be established, one vexing question remains: How much evidence is sufficient to support conclusions about the effectiveness of a particular resource management or allocation strategy? For example, one high-quality study included in the review—not summarized above—reported the results of a policy restricting ambulatory and inpatient care of nonurgent cases among 32 hospitals in the greater Toronto area during the 2003 SARS epidemic.[37] Can a single study, no matter how compelling, constitute sufficient evidence to support conclusions about the value of a particular policy? In the absence of consensus evidence hierarchies or other rubrics specific to mass casualty events, providers and policymakers may interpret evidence differently and therefore reach different conclusions. Developing evidentiary standards through consensus among relevant experts could promote swift adoption of effective strategies into disaster planning.

Given the near certainty that large-scale mass casualty events will continue to occur, and the high cost and relative scarcity of health care services on a typical day, it is deeply concerning how little high-quality evidence is available to help policymakers, health care providers, and the public determine the best course of action during mass casualty events. Although we identified findings that support the utility of a few interventions, the overall body of evidence is far from definitive. Because mass casualty events do not lend themselves to criterion-standard randomized controlled trials, nonexperimental study designs must be used. However, the absence of methodological and evidentiary standards, the challenges of conducting ethical research during a mass casualty event, and competing funding priorities at the federal, state, and local levels create formidable barriers to advancing the research in this area. Nevertheless, we believe our findings can serve as a key starting point for disaster researchers, first responders, and program evaluators across the nation.

In summary, the current evidence base appears inadequate to inform providers and policymakers about the most effective strategies for managing or allocating scarce resources during mass casualty events. Very limited evidence suggests that points of dispensing can be used to efficiently distribute biological countermeasures after a bioterrorism attack or influenza pandemic, and different models may vary in their effectiveness. Some evidence also suggests that commonly used field triage systems do not perform consistently during actual mass casualty events. Few strategies were evaluated in more than 2 studies, and heterogeneity in outcome measures and context prevented quantitative synthesis of results. Improving the evidence base will require a diverse group of policymakers, funders, and nongovernmental experts to come together to craft a well-organized and coordinated program of applied research[38] that adheres to appropriate ethical and methodological standards.

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Appendix E1. PRISMA Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2-3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4-5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	Previously posted; no longer available on AHRQ website.
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	5; Appendix B
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Appendix B
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5-6
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Appendix D; also see full report
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	6
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	NA
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	NA
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	NA
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	NA
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	18; Appendix C
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Appendix D
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Appendix D
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	NA
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	NA
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	NA
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	NA
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	14
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	12

Appendix E1. Continued.

Section/topic	#	Checklist item	Reported on page #
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	15
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	1

Appendix E2. Literature search terms

INITIAL SEARCHES RAN JANUARY 21, 2011, COVERING 1990-January 2011.
FINAL UPDATE SEARCHES PERFORMED ON NOVEMBER 8, 2011 COVERING JANUARY 2011-NOVEMBER 2011.

SEARCH #1 (updated 11/8/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
PubMed 2011-2011
SEARCH STRATEGY:
disasters[mesh] OR disaster*[tiab] OR emergencies OR emergency planning OR emergency preparedness OR mass casualt* OR ((triage[ti] OR triaging[ti]) AND disaster*) OR pandemic[ti]
AND
surge OR scarce OR scarcity OR allocat* OR ration OR mass OR (triage AND (ethic* OR protocol)) OR "emergency medical care" OR (emergency medical care services[mh] AND ration) OR remote consultation[mh] OR “crisis standards” OR “altered care” OR “adapted care” OR “crisis standards of care” OR “altered standards of care”
NOT: Letters, Case Reports, Clinical Trials
NOT: animal*NOT Human*
NOT :("human remains" OR "identifying human bodies" OR autops* OR "end of life planning" OR pig OR pigs OR porcine OR cow OR cows OR bovine OR horse OR horses OR dog OR dogs OR cat OR cats OR mice OR mouse OR hamster OR hamsters OR rat OR rats OR "identification of human bodies" OR epidemiology OR appendectomy OR “dental identification” OR "water insecurity" OR "mass gatherings" OR "dental identification" OR (food AND ration) OR clinicaltrials.gov OR "total hip replacement" OR (mass AND cancer) OR ECMO OR forensic* OR drought OR “abdominal aortic aneurysm” OR (oil AND spill) OR “global warming” OR “partner violence” OR “violence prevention”)

NUMBER OF ITEMS RETRIEVED: 223

SEARCH #2 (updated 11/8/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
CINAHL – 2011-2011
(Disaster* OR emergencies OR emergency planning OR emergency preparedness OR mass casualt* OR ((TI triage OR TI triaging) AND disaster*) OR TI pandemic)
AND
(surge OR scarce OR scarcity OR allocat* OR (triage AND (ethic* OR protocol) OR "emergency medical care" OR ("emergency medical services" AND ration) OR "remote consultation" OR "crisis standards" OR "altered care" OR "adapted

care" OR "crisis standards of care" OR "altered standards of care")
And Human
Not Letters

Limiters - Date of Publication from: 20110101-20111231; Peer Reviewed; Exclude MEDLINE records; Human

NUMBER OF ITEMS RETRIEVED: 7 (1 duplicate) = 6
SEARCH #3 (updated 11/8/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
Cochrane – 2011-2011
“mass casualt*” OR “disaster preparedness” OR (Triag* AND (disaster OR mass))
NUMBER OF ITEMS RETRIEVED: 6
SEARCH #4 (RUN 11/8/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
Embase – 2011-2012
'mass disaster'/exp OR disaster*:ab,ti OR 'emergencies'/exp OR 'emergency'/exp AND 'planning'/exp OR 'emergency'/exp AND preparedness OR 'mass'/exp AND casualt* OR ((triage:ti OR triaging:ti)AND disaster*) OR pandemic:ti AND [embase]/lim
AND
'emergency medical care'/exp OR ('emergency medical services'/exp AND ration) OR 'remote consultation'/exp OR 'crisis standards' OR 'altered care' OR 'adapted care' OR 'crisis standards of care' OR 'altered standards of care' OR surge OR scarce OR scarcity OR allocat* OR ration OR 'mass'/exp OR ('triage'/exp AND (ethic* OR protocol)) AND [embase]/lim
AND [humans]/lim AND [1990-2011]/py
NOT
pandemic NEAR/3 vaccin*
NUMBER OF ITEMS RETRIEVED: 21 results (8 duplicates) = 13 results
SEARCH #5 (updated 11/8/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
Web of Science – 2011-2011
TS=disaster* OR TS=emergencies OR TS=emergency planning OR TS=emergency preparedness OR TS=mass casualt* OR (TI=triage OR TI=triaging) AND TS=disaster*) OR TI=pandemic
AND
TS=surge OR TS=scarce OR TS=scarcity OR TS=allocat* OR TS=triage AND TS= (ethic* OR protocol) OR TS="emergency medical care" OR TS= ("emergency medical services" AND ration) OR TS="remote consultation" OR TS="emergency medical care" OR TS= ("emergency medical services" AND ration) OR TS="remote consultation" OR TS="crisis standards" OR TS="altered care" OR TS="adapted care" OR TS="crisis standards of care" OR TS="altered standards of care"
NOT: Letter

NOT :
(TS="human remains" OR TS="identifying human bodies" OR TS=autops* OR TS="end of life planning" OR TS=pig OR TS=pigs OR TS=porcine OR TS=cow OR TS=cows OR TS=bovine OR TS=horse OR TS=horses OR TS=dog OR TS=dogs OR TS=cat OR TS=cats OR TS=mice OR TS=mouse OR TS=hamster OR TS=hamsters OR TS=rat OR TS=rats OR TS="identification of human bodies" OR TS=epidemiology OR TS=appendectomy OR TS= “dental identification” OR TS="water insecurity" OR TS="mass gatherings" OR TS="dental identification" OR TS= (food AND ration) OR TS=clinicaltrials.gov OR TS="total hip replacement" OR TS= (mass AND cancer) OR TS=ECMO OR TS=forensic* OR TS=drought OR TS=“abdominal aortic aneurysm” OR TS= (oil AND spill) OR TS=“global warming” OR TS= “partner violence” OR TS= “violence prevention” OR TS=geological OR TS="clinical trial" OR TS="urban modeling" OR TS="urban simulation" OR)

Refined by: [excluding] Subject Areas=(ENGINEERING, MECHANICAL OR WATER RESOURCES OR ECOLOGY OR CONSTRUCTION & BUILDING TECHNOLOGY OR MATHEMATICS, INTERDISCIPLINARY APPLICATIONS OR ENGINEERING, GEOLOGICAL OR METEOROLOGY & ATMOSPHERIC SCIENCES OR VETERINARY SCIENCES OR ENGINEERING, OCEAN OR MEDICAL INFORMATICS OR OCEANOGRAPHY)
NUMBER OF ITEMS RETRIEVED: 273 (before deduping); 227 after de-duping

SEARCH #6 (RUN 11/10/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
Global Health – 1990-2011
1 S DISASTER? OR MASS()CASUALT? OR EMERGENCY(5N)PLAN? OR EMERGENCY(5N)PREPAR? OR EMERGENCY()MEDICAL()CARE OR REMOTE()SERVICES OR EMERGENCIES OR PANDEMIC?
S2 S TRIAG?/TI AND DISASTER?
S3 S S1 OR S2
S4 S SURGE OR SCARCE OR SCARCITY OR ALLOCAT? OR RATION OR RATIONED OR RATIONING OR MASS
S5 S TRIAGE AND (ETHIC? OR PROTOCOL?)
S6 S S3 OR S4
S7 S S3 AND S6
S8 S S3 AND S4
S9 S S8 OR S5
S10 S EMERGENCY()MEDICAL()CARE()SERVICE? AND (RATION OR RATIONED OR RATIONING)
S11 S EMERGENCY()MEDICAL AND (RATION OR RATIONED OR RATIONING)
S12 S REMOTE?(2N)CONSULT?
S13 S CRISIS(2N)STANDARD? OR ALTERED()CARE OR ADAPTED()CARE
S14 S S9 OR S11 OR S12 OR S13

S15 S S14/ENG
S16 S S15/1990:2011
NUMBER OF ITEMS RETRIEVED: 137 – 51 duplicates – 86

SEARCH #7 (RUN 4/16/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
SCOPUS – 1990-2011

TITLE-ABS-KEY(disaster*) OR emergencies OR {emergency planning} OR emergency preparedness OR mass casualt* OR TITLE(triage) OR TITLE(pandemic)
AND
surge OR scarce OR scarcity OR allocat* OR ration OR mass OR (triage AND (ethic* OR protocol))
OR({emergency medical care} OR {remote consultation}) AND ration OR {crisis standards} OR {altered care} OR {adapted care} OR {crisis standards of care} OR {altered standards of care} OR {crisis care}
AND
PUBYEAR AFT 2011
NOT
{human remains} OR {identifying human bodies} OR autops* OR {end of life planning} OR pig OR pigs OR porcine OR cow OR cows OR bovine OR horse OR horses OR dog OR dogs OR cat OR cats OR mice OR mouse OR hamster OR hamsters OR rat OR rats OR {identification of human bodies} OR epidemiology OR appendectomy OR {dental identification} OR {water insecurity} OR {mass gatherings} OR {dental identification} OR (food AND ration) OR clinicaltrials.gov OR {total hip replacement} OR (mass AND cancer) OR ecmo OR forensic* OR drought OR {abdominal aortic aneurysm} OR (oil AND spill) OR {global warming} OR {partner violence} OR {violence prevention})
NUMBER OF ITEMS RETRIEVED: 218 -114(weeding) – 45 (deduping)= 59

SEARCH #8 (updated 11/8/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
NLMLocatorPlus– 2011-2011
Mass Casualty as a phrase in Title
OR
Disaster in Title
AND
Medicine in Title

NUMBER OF ITEMS RETRIEVED: 15 titles kept 3
(these are in a separate .txt file: NLMupdatedresults.txt)

SEARCH #9 (RUN 11/14/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
NYAM Grey Literature Report– 2011-
Key word: mass casualty OR disaster OR disasters
NUMBER OF ITEMS RETRIEVED: 12

(these citations are in a separate word document: NYAM_UpdateDisaster_MassCasualty_11_2011.doc)

SEARCH #1 (RUN 1/21/2011)

DATABASE SEARCH & TIME PERIOD COVERED:

PubMed – 1990-2011

SEARCH STRATEGY:

disasters[mesh] OR disaster*[tiab] OR emergencies OR emergency planning OR emergency preparedness OR mass casualt* OR ((triage[ti] OR triaging[ti]) AND disaster*) OR pandemic[ti]

AND

surge OR scarce OR scarcity OR allocat* OR ration OR mass OR (triage AND (ethic* OR protocol)) OR "emergency medical care" OR (emergency medical care services[mh] AND ration) OR remote consultation[mh] OR “crisis standards” OR “altered care” OR “adapted care” OR “crisis standards of care” OR “altered standards of care”

NOT: Letters, Case Reports, Clinical Trials

NOT: animal*NOT Human*

NOT :("human remains" OR "identifying human bodies" OR autops* OR "end of life planning" OR pig OR pigs OR porcine OR cow OR cows OR bovine OR horse OR horses OR dog OR dogs OR cat OR cats OR mice OR mouse OR hamster OR hamsters OR rat OR rats OR "identification of human bodies" OR epidemiology OR appendectomy OR “dental identification” OR "water insecurity" OR "mass gatherings" OR "dental identification" OR (food AND ration) OR clinicaltrials.gov OR "total hip replacement" OR (mass AND cancer) OR ECMO OR forensic* OR drought OR “abdominal aortic aneurysm” OR (oil AND spill) OR “global warming” OR “partner violence” OR “violence prevention”)

OR:

Levin D[au] AND pandemic[ti]

NUMBER OF ITEMS RETRIEVED: 2472

SEARCH #2 (RUN 1/27/2011)

DATABASE SEARCH & TIME PERIOD COVERED:

CINAHL – 1990-2011

Disaster* OR emergencies OR emergency planning OR emergency preparedness OR mass casualt* OR ((TI triage OR TI triaging) AND disaster*) OR TI pandemic

AND

surge OR scarce OR scarcity OR allocat* OR (triage AND (ethic* OR protocol) OR "emergency medical care" OR ("emergency medical services" AND ration) OR "remote consultation" OR "crisis standards" OR "altered care" OR "adapted care" OR "crisis standards of care" OR "altered standards of care"

And Human

Not Letters

Date of Publication from: 19900101-20111231; Peer Reviewed; Exclude MEDLINE records

NUMBER OF ITEMS RETRIEVED: 83 (AFTER DEDUPING) 76

SEARCH #3 (RUN 1/27/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
Cochrane – 1990-2011
"mass casualt*" OR "disaster preparedness" OR (Triag* AND (disaster OR mass))
NUMBER OF ITEMS RETRIEVED: 56
SEARCH #4 (RUN 1/27/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
Embase – 1990-2011
'mass disaster'/exp OR disaster*:ab,ti OR 'emergencies'/exp OR 'emergency'/exp AND 'planning'/exp OR 'emergency'/exp AND preparedness OR 'mass'/exp AND casualt* OR ((triage:ti OR triaging:ti)AND disaster*) OR pandemic:ti AND [embase]/lim
AND
'emergency medical care'/exp OR ('emergency medical services'/exp AND ration) OR 'remote consultation'/exp OR 'crisis standards' OR 'altered care' OR 'adapted care' OR 'crisis standards of care' OR 'altered standards of care' OR surge OR scarce OR scarcity OR allocat* OR ration OR 'mass'/exp OR ('triage'/exp AND (ethic* OR protocol)) AND [embase]/lim
AND [humans]/lim AND [1990-2011]/py
NOT
pandemic NEAR/3 vaccin*
NUMBER OF ITEMS RETRIEVED: 129 results (before de-duping) 70 (after de-duping & hand removal)
SEARCH #5 (RUN 1/27/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
Web of Science – 1990-2011
TS=disaster* OR TS=emergencies OR TS=emergency planning OR TS=emergency preparedness OR TS=mass casualt* OR (TI=triage OR TI=triaging) AND TS=disaster*) OR TI=pandemic
AND
TS=surge OR TS=scarce OR TS=scarcity OR TS=allocat* OR TS=triage AND TS= (ethic* OR protocol) OR TS="emergency medical care" OR TS= ("emergency medical services" AND ration) OR TS="remote consultation" OR TS="emergency medical care" OR TS= ("emergency medical services" AND ration) OR TS="remote consultation" OR TS="crisis standards" OR TS="altered care" OR TS="adapted care" OR TS="crisis standards of care" OR TS="altered standards of care"
NOT: Letter
NOT :
(TS="human remains" OR TS="identifying human bodies" OR TS=autops* OR TS="end of life planning" OR TS=pig OR TS=pigs OR TS=porcine OR TS=cow OR TS=cows OR TS=bovine OR TS=horse OR TS=horses OR TS=dog OR TS=dogs OR TS=cat OR TS=cats OR TS=mice OR TS=mouse OR TS=hamster OR TS=hamsters OR TS=rat OR TS=rats OR TS="identification of human bodies" OR TS=epidemiology OR TS=appendectomy OR TS= "dental

identification" OR TS="water insecurity" OR TS="mass gatherings" OR TS="dental identification" OR TS= (food AND ration) OR TS=clinicaltrials.gov OR TS="total hip replacement" OR TS= (mass AND cancer) OR TS=ECMO OR TS=forensic* OR TS=drought OR TS="abdominal aortic aneurysm" OR TS= (oil AND spill) OR TS="global warming" OR TS= "partner violence" OR TS= "violence prevention" OR TS=geological OR TS="clinical trial" OR TS="urban modeling" OR TS="urban simulation" OR)

Refined by: [excluding] Subject Areas=(ENGINEERING, MECHANICAL OR WATER RESOURCES OR ECOLOGY OR CONSTRUCTION & BUILDING TECHNOLOGY OR MATHEMATICS, INTERDISCIPLINARY APPLICATIONS OR ENGINEERING, GEOLOGICAL OR METEOROLOGY & ATMOSPHERIC SCIENCES OR VETERINARY SCIENCES OR ENGINEERING, OCEAN OR MEDICAL INFORMATICS OR OCEANOGRAPHY)
NUMBER OF ITEMS RETRIEVED: 748 (before deduping); 506 after de-duping (and screening)

SEARCH #6 (RUN 2/1/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
Global Health – 1990-2011

1 10670 S DISASTER? OR MASS()CASUALT? OR EMERGENCY(5N)PLAN? OR EMERGENCY(5N)PREPAR? OR EMERGENCY()MEDICAL()CARE OR REMOTE()SERVICES OR EMERGENCIES OR PANDEMIC?
S2 16 S TRIAG?/TI AND DISASTER?
S3 10670 S S1 OR S2
S4 93610 S SURGE OR SCARCE OR SCARCITY OR ALLOCAT? OR RATION OR RATIONED OR RATIONING OR MASS
S5 54 S TRIAGE AND (ETHIC? OR PROTOCOL?)
S6 103284 S S3 OR S4
S7 10670 S S3 AND S6
S8 996 S S3 AND S4
S9 1026 S S8 OR S5
S10 0 S EMERGENCY()MEDICAL()CARE()SERVICE? AND (RATION OR RATIONED OR RATIONING)
S11 1 S EMERGENCY()MEDICAL AND (RATION OR RATIONED OR RATIONING)
S12 21 S REMOTE?(2N)CONSULT?
S13 3 S CRISIS(2N)STANDARD? OR ALTERED()CARE OR ADAPTED()CARE
S14 1048 S S9 OR S11 OR S12 OR S13
S15 974 S S14/ENG
S16 930 S S15/1990:2011

NUMBER OF ITEMS RETRIEVED: 930

SEARCH #7 (RUN 4/16/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
SCOPUS – 1990-2011

TITLE-ABS-KEY(disaster*) OR emergencies OR {emergency planning} OR emergency preparedness OR mass casualt* OR TITLE(triage) OR TITLE(pandemic) AND
surge OR scarce OR scarcity OR allocat* OR ration OR mass OR (triage AND (ethic* OR protocol))

OR({emergency medical care} OR {remote consultation}) AND ration OR
{crisis standards} OR {altered care} OR {adapted care} OR {crisis standards of care} OR
{altered standards of care} OR {crisis care}
AND
PUBYEAR AFT 1989
NOT
{human remains} OR {identifying human bodies} OR autops* OR {end of life planning} OR pig OR pigs OR porcine OR cow OR cows OR bovine OR horse OR horses OR dog OR dogs OR cat OR cats OR mice OR mouse OR hamster OR hamsters OR rat OR rats OR {identification of human bodies} OR epidemiology OR appendectomy OR {dental identification} OR {water insecurity} OR {mass gatherings} OR {dental identification} OR (food AND ration) OR clinicaltrials.gov OR {total hip replacement} OR (mass AND cancer) OR ecmo OR forensic* OR drought OR {abdominal aortic aneurysm} OR (oil AND spill) OR {global warming} OR {partner violence} OR {violence prevention})
NUMBER OF ITEMS RETRIEVED: after deduping 1270 – after weeding 428

SEARCH #8 (RUN 1/28/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
NLMLocatorPlus– 1990-2011
Mass Casualty as a phrase in Title
OR
Disaster in Title
AND
Medicine in Title

NUMBER OF ITEMS RETRIEVED: 141 titles kept 42

SEARCH #9 (RUN 1/31/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
NYAM Grey Literature Report– 1990-2011
Key word: mass casualty OR disaster OR disasters
NUMBER OF ITEMS RETRIEVED: 290

Appendix E3. Excluded titles

Title Exclusions during Short Form Review Stage

Did not address a key question (n=691)

1. *A 2002 national assessment of state trauma system development, emergency medical services resources, and disaster readiness for mass casualty events*: [Washington, D.C.] : U.S. Dept. of Health and Human Services, Health Resources and Services Administration, [2003].
2. *Supplement A. Command and Control , Incident Command and Management System* Public Health Guidance for Community-Level Preparedness and Response to Severe Acute Respiratory Syndrome (SARS) Version 2: Department of Health and Human Services, Centers for Disease Control and Prevention.
3. Special report. The Oklahoma City bombing: mass casualties and the local hospital response. *Hosp Secur Saf Manage.* Sep 1995;16(5):5-10.
4. *Establishing a mass casualty management system*. Washington, D.C.: Pan American Health Organization, Pan American Sanitary Bureau, Regional Office of the World Health Organization; 1995.
5. Few problems for hospitals treating speedway walkway collapse victims. *Hosp Secur Saf Manage.* Sep 2000;21(5):13-14.
6. Expect 2 waves of patients after terrorist attack. *ED Manag.* Jan 2000;12(1):8-9.
7. VETERANS HEALTH ADMINISTRATION EMERGENCY MANAGEMENT PROGRAM PROCEDURES: Department of Veteran s Affairs Veterans Health Administration; 2000.
8. What's the ASC's role for mass casualties? *OR Manager.* Nov 2002;18(11):23-25.
9. New aspects in mass casualties. *Anasthesiol Intensivmed Notfallmed Schmerzther.* Sep 2002;37(9):537-538.
10. Collaboration and coordination in mass casualty disaster plans. *Healthc Hazard Manage Monit.* Jan 2002;15(5):1-7.
11. Guidelines for the use of foreign field hospitals in the aftermath of sudden-impact disaster. *Prehosp Disaster Med.* Oct-Dec 2003;18(4):278-290.
12. Checklists for mass casualty disaster plans. *Disaster Management and Response.* 2003;1(1):31.
13. Is it OK to have someone very quickly screen incoming patients? *ED Manag.* Jan 2004;16(1):8-9.
14. Staffing up helps EDs handle Katrina surge. *ED Manag.* Oct 2005;17(10):112-113.
15. Disaster relief. Hurricane victims with HIV/AIDS overwhelm resources. *AIDS Policy Law.* Sep 23 2005;20(18):1, 4.
16. Health care system surge capacity recognition, preparedness, and response. *Ann Emerg Med.* Feb 2005;45(2):239.
17. Riding out the surge. *JEMS: Journal of Emergency Medical Services.* 2005;30(11):42-42.
18. *Altered standards of care in mass casualty events*. Rockville, MD: Agency for Healthcare Research and Quality; 2005.
19. Proceedings of the Consensus Conference "The Science of Surge", May 17, 2006, San Francisco, California, USA. *Acad Emerg Med.* Nov 2006;13(11):1087-1253.
20. Office of the Assistant Secretary for Preparedness and Response; HHS Public Health Emergency Medical Countermeasures Enterprise implementation plan for chemical, biological, radiological and nuclear threats. Notice. *Fed Regist.* Apr 23 2007;72(77):20117-20128.
21. AORN guidance statement: mass casualty, triage, and evacuation. *AORN J.* Apr 2007;85(4):792, 794-795,797-800.
22. *National disaster management guidelines*. New Delhi: National Disaster Management Authority; 2007.
23. *Improving health system preparedness for terrorism and mass casualty events : recommendations for action : a consensus report from the AMA/APHA Linkages Leadership Summit, Chicago (July 7-8, 2005), New Orleans (June 7-8, 2006)* [computer program]: Chicago, IL : American Medical Association : American Public Health Association; 2007.
24. *DEPARTMENT OF VETERANS AFFAIRS AND DEPARTMENT OF DEFENSE CONTINGENCY PLAN*: Department of Veteran s Affairs Veterans Health Administration;2007.

25. HIV PEP rarely warranted after mass casualties. CDC guidelines for HIV, hepatitis and tetanus. *AIDS Alert.* Sep 2008;23(9):107-108.

26. ED handles 30 burn patients after plant fire and explosion in Georgia. *ED management : the monthly update on emergency department management.* 2008;20(4):37-39.

27. Wireless Sensor Networks - 5th European Conference, EWSN 2008, Proceedings. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics).* Vol 4913 LNCS. Bologna2008.

28. Flight 1404. The response and lessons learned from the crash at Denver International Airport. *JEMS.* Sep 2009;34(9):36-43, 45.

29. 'Reverse triage' adds to surge capacity. *ED Manag.* Jun 2009;21(6):64-65.

30. Abstracts of note: the bioethics literature. *Cambridge Quarterly of Healthcare Ethics.* 2010;19(1):154-156.

31. *Preparedness and Response to a Rural Mass Casualty Incident: Workshop Summary*. Washington DC: National Academy of Sciences.; 2011.

32. EDs credit drills, community engagement with helping them manage casualties from tornado crises. *ED Manag.* Jul 2011;23(7):73-76.

33. *Minnesota Department of Health All-Hazards Response and Recovery Base plan*: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, and Assistant Secretary for Preparedness and Response;June 2009.

34. *Project ER One.* Dirksen BuildingMay 8, 2003.

35. *Alabama Preparedness Guide 001 (APG 001): A Guide for State, Tribal, and Local Governments* Alabama Emergency Management Agency;November 2009.

36. Aaby K., Cook D, Herrmann J, Jordan C, Wood K. Simulating a mass vaccination clinic: Health Care Management Science. 2008; http://www.isr.umd.edu/Labs/CIM/projects/clinic/hcms.pdf. Accessed December 30, 2008.

37. Aacharya RP, Gastmans C, Denier Y. Emergency department triage: an ethical analysis. *BMC Emerg Med.* 2011;11:16.

38. Ablah E, Konda K, Kelley CL. Factors Predicting Individual Emergency Preparedness: A Multi-State Analysis of 2006 Brfss Data. *Biosecurity and Bioterrorism-Biodefense Strategy Practice and Science.* Sep 2009;7(3):317-330.

39. Ablah E, Konda KS, Konda K, Melbourne M, Ingoglia JN, Gebbie KM. Emergency preparedness training and response among community health centers and local health departments: results from a multi-state survey. *J Community Health.* Jun 2010;35(3):285-293.

40. Ablah E, Nickels D, Hodle A, Wolfe DJ. Public health investigation: focus group study of a regional infectious disease exercise. *Public Health Nurs.* Nov-Dec 2008;25(6):546-553.

41. Acosta J, Stern S, Uscher-Pines L, et al. *Building community resilience to disasters*2011.

42. Adams HA. Patient care in mass casualty disaster: Statement of the interdisciplinary working group on shock of the DIVI. *Patientenversorgung im katastrophenfall: Stellungnahme der interdisziplinären arbeitsgruppe (IAG) schock der deutschen interdisziplinären vereinigung für intensivmedizin und notfallmedizin (DIVI).* 2006;109(7):583-586.

43. Adams K. The South Carolina Nurses Association unveils preliminary findings of the nursing school survey on competencies for entry-level registered nurses related to mass casualty incidents. *S C Nurse.* Oct-Dec 2005;12(4):1.

44. Adini B, Cohen R, Bar-Dayan Y. Risk and protective factors that impact survival in emergencies--the time has come for an upgrade in preventive emergency population behavior. *Prehosp Disaster Med.* Nov-Dec 2008;23(6):507-509.

45. Adini B, Goldberg A, Cohen R, Bar-Dayan Y. Relationship Between Standards of Procedures for Pandemic Flu and Level of Hospital Performance in Simulated Drills. *Annals of Emergency Medicine.* 2008;52(3):223-229.

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Appendix E4. D-1. Strategies to reduce or manage less urgent demand for health care resources

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Arora, 2010[1]	Allocation of Biological counter-measures *Also in Augment resources	Not relevant	Computer simulation	N/A	Infectious disease: Influenza	1) Determine what proportion of CDC stockpile to preallocate in response to pandemic flu outbreak. 2) Implement mutual aid agreements that allow transshipment of antivirals between counties. 3) Allocate CDC stockpile according to age group, gross attack rate, or population only. 4) Determine what proportion of CDC stockpile to use for prophylaxis vs. treatment for pandemic flu outbreak.	Postponing allocation is optimal by allowing allocation according to the infected population rather than the susceptible population. Transshipment through mutual aid agreements is an optimal policy when infection rates vary across counties and counties with small populations are affected. Allocate CDC antiviral stockpile according to gross attack rates rather than population is the optimal strategy. Age-based allocation may also be optimal. Limit use of CDC antiviral stockpile for prophylaxis when supplies are limited and focus on treatment instead.	Vaccine effectiveness is lower among the elderly	4/7
Bravata, 2006[2]	Allocation of Biological counter-measures	Not relevant	Computer simulation	N/A	Infectious disease: Anthrax	Comparison of broad categories of strategies, including: (1) enhancing bioterrorism event detection, (2) increasing local dispensing capacity, (3) increasing local inventories of antibiotics, and (4) increasing the amount of inventory deployed from the SNS to the site of an attack.	Surveillance strategies to enhance attack detection do not result in reduced mortality when dispensing capacity is low. Increasing local antibiotic stockpiles and instituting surveillance systems to reduce the delay in attack detection, are cost-effective only if the community can achieve a high dispensing capacity, if the probability of an attack is greater than 0.0001 per year, and if the attack is large.	N/A	7/9

Appendix E4. D-1. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Glasser, 2010[3]	Allocation of Biological counter-measures	Not relevant	Computer simulation	N/A	Infectious disease: Influenza	Target pandemic flu vaccine to specific demographic groups	A strategy of vaccinating children, adolescents, and young adults reduced morbidity the most during a simulated pandemic, while a strategy of vaccinating infants, older adults, and young adults had the largest impact on reducing mortality.	N/A	2/7
McCaw, 2008[4]	Allocation of Biological counter-measures	Not relevant	Computer simulation	N/A	Infectious disease: Influenza	Optimal strategy for allocation of antivirals from the Strategic National Stockpile (SNS) during an influenza pandemic (if there ARE two effective drugs)	The two drug strategy (give a different drug to Cases versus their Contacts – i.e. use a different drug for treatment versus prophylaxis) is superior to other strategies because it produces greater delays in: a) propagation of the epidemic and b) the emergence of drug resistance (including multi-drug resistance), but when resistance does emerge, it is more likely to be multi-drug resistance.	The implications of multidrug resistance are strongly dependent on the relative fitness of mutant strains, with the potential for either reduced or extended delays to an uncontrolled outbreak. Strategies that allocate different drugs to treated cases and their close contacts are likely to be most effective at constraining the rate of resistance emergence	7/9
McVernon, 2010[5]	Allocation of Biological counter-measures	Not relevant	Computer simulation	N/A	Infectious disease: Influenza	Continuous pre-exposure prophylaxis for health care workers during a influenza pandemic	Provision of continuous pre-exposure prophylaxis to 300,000 HCWs consumed 46% of the stockpile over 18 weeks. While appreciably depleting resources, such use had a negligible impact on the containment effort. Continuous distribution of antiviral prophylaxis to healthcare workers (HCWs)is considered necessary in the early phases of the pandemic response to ensure continuity of healthcare services, the finding suggest it does not compromise population disease control.	N/A	4/7

Appendix E4. D-1. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Medlock, 2009[6]	Allocation of Biological counter-measures	Not relevant	Computer simulation	N/A	Infectious disease: Influenza	Model to determine optimal vaccine allocation strategy for mass prophylaxis to a novel virus	Mortality (relative to status quo strategy) and other outcomes were usually most reduced by vaccinating children 5-19 years old (highest transmission group) and child-rearing aged adults (30-39 years), but reduced mortality by 20-40% relative to current CDC recommendations.	Optimal strategy depends on which outcome gets priority (deaths averted, life years saved, etc.) Outcome depends on age-group related transmission rate Outcome depends on age-specific mortality Outcome depends on age-specific vaccine efficacy	5/9
Wein, 2003[7]	Allocation of Biological counter-measures *Also in Augment resources	Not relevant	Computer simulation	N/A	Infectious disease: Anthrax	1) Aggressive and rapid antibiotic distribution post Anthrax mass attack detection 2) Dramatically expanded POD & hospital surge capacity (for example by cross training, and using non-hospital volunteers to extend trained personnel, and mobile servers from other federal agencies to provide hospital surge capacity)	The Number of Deaths (relative to base case strategy of no or very delayed treatment) is a function of the speed of distribution - Mass antibiotic distribution reduces deaths to 123,000 (8.3% of base case) versus 660,000 deaths (44% of base case) if only symptomatic patients are treated Number of Deaths (relative to base case strategy) - function of hospital capacity - dramatically decreased with sufficient personnel - ten-fold or more, and mobile servers (e.g., from other federal agencies)	Antibiotic Efficacy Adherence to prophylactic regimen Adding mobile servers (to provide surge hospital care) is more effective than adding local servers because the former are typically less busy and therefore more available.	5/9
Zenihana, 2010[8]	Allocation of Biological counter-measures	Not relevant	Computer simulation	N/A	Infectious disease: Smallpox	A combination of mass vaccination, contact tracing and vaccination, and school closure as countermeasures to a smallpox bioterrorism attack	A combination of mass vaccination and contact tracing and vaccination can lead to lower mortality, quicker eradication, and less vaccine use than either strategy separately. School closure potentiates the effect of all strategies.	Time required to trace contacts Number of days between index patient and start of countermeasures 1-day vs. 2-day mass vaccination periods	3/7

Appendix E4. D-1. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Zaric, 2008[9]	Allocation of Biological counter-measures	Not relevant	Computer simulation	N/A	Infectious disease: Anthrax	Develop a model to optimize the logistical response to a bioterrorism event.	The demonstration model provides the following insights: (1) communities should focus on dispensing capacity rather than stockpiling of supplies. (2) improved surveillance can reduce mortality if adequate dispensing capacity exists. (3) the mortality from an attack is significantly affected by the number of unexposed individuals who seek prophylaxis and treatment.	N/A	3/9
Ablah, 2010[10]	Distribution of biological counter-measures	Nassau Co, NY	Exercise, drill, or training program	Post only with comparison group: Hybrid POD model	Infectious disease: Anthrax	Use of centralized POD model, as compared with a hybrid POD model.	Centralized POD model had slightly faster processing time than the hybrid model. Centralized and hybrid models had similar quality control outcomes overall. However, hybrid models were more likely to follow the individual steps in the protocol designed to reduce medication error. Centralized PODs were slightly more accurate in dispensing the correct medication. Centralized POD processed 0.75 patients/minute, compared with 0.48 patients per minute.	This only looked at 1st responder/receivers and family, not general population.	6/8
Erwin, 2009[11]	Distribution of biological counter-measures	US	Analysis of single real event	Post only with comparison group: Benchmark	Infectious disease: Smallpox	Use CDC smallpox post-exposure clinic guidelines to establish an emergency mass clinic. (The guidelines were implemented during a Hepatitis A outbreak.)	Time per patient - mean: 10 minutes for individuals and mean: 3.5 minutes for groups Immunizations (actual demand) per staff-hour - 1.45 immunizations per staff-hour (versus CDC benchmark of 1.58 immunizations per staff-hour)	N/A	4/8

Appendix E4. D-1. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Hupert, 2009[12]	Distribution of biological counter-measures	Not relevant	Computer simulation	N/A	Infectious disease: Anthrax	Account for temporal variability in patient arrivals by dynamically adjusting staffing to meet demand in point-of-dispensing stations for mass prophylaxis using Dynamic POD Simulator	For a given number of staff hours, dynamic changes in staffing in response to demand can increase the capacity (number of patients treated) of a POD station.	Ability to accurately forecast future arrivals based upon current demand might be limited	2/7
Koh, 2008[13]	Distribution of biological counter-measures	Boston, MA	Exercise, drill, or training program	Post only with comparison group: Implicit benchmark standard	Infectious disease: Anthrax	1) A streamlined Point of Dispensing (POD) strategy for mass distribution of antibiotics within 48 hours after an Anthrax release. 2) A push method of dispensing (via U.S. Postal Service mail carriers) for mass distribution of antibiotics within 48 hours after an Anthrax attack	Number of people served per hour via POD (relative to benchmark standard)- 1988 person/hour (about 33/hour/staff person) Number of people served per hour via mail carrier - 23,000 persons in 6 hours (120 people/hour/carrier)	Heads of household can pick up meds for all No identification requirement to register Preregistered/trained staff insufficient for probable demand Innovation in training: online and tailored to background (clinical/nonclinical) and commitment (response/leadership Neighborhood-centric strategy for selecting PODs was seen as important	6/8

Appendix E4. D-1. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Lee, 2006[14]	Distribution of biological counter-measures	Atlanta, Georgia	Exercise, drill, or training program	Post only with comparison group: 7 counties not using decision support software	Infectious disease: Anthrax	Use of integrated simulation and decision-support software (RealOpt) to determine appropriate staffing for point of dispensing medical countermeasure following Anthrax release.	DeKalb County, the only county participating in the point of dispensing exercise that used RealOpt, achieved the highest throughput compared to all other participating counties. DeKalb was the only county to exceed 450 targeted households; its throughput was 50% higher than the next highest county (which processed only 71% of target households). External evaluators reported that DeKalb County produced the most efficient floor plan (with no path crossing), the most cost-effective dispensing (lowest labor/throughput value), and the smoothest operations (shortest average wait time, average queue length, and equalized utilization rate). No quantitative measures were reported for these parameters.	Computation time for a simulation required <1 minuted CPU time, compared to 5-10 hours for existing commercial software. Combined computation time (using RealOpt) for total 860,000 households was 30 minutes.	4/8
Adini, 2010[15]	Nonbiological counter-measures	Israel	Analysis of multiple real events	Pre-post	All-hazards	Use a standardized, automated central information distribution system for hospitals to help family members locate and identify MCE victims	Overload of hospital communication lines occurred frequently during MCEs, prior to deploying the central information system, but has never happened since implementing the system	N/A	4/8

Appendix E4. D-1. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Cahill, 2008[16]	Non-biological counter-measures	Not relevant	Computer simulation	N/A	Infectious disease: Influenza	Distribute surgical masks or N95 respirators to the public to limit the spread of pandemic influenza (both droplet and airborne transmission).	Use of N95 respirators lowers the probability of infection and the percentage of the population infected compared to surgical masks. Estimated outpatient visits for the N95 mask (100% compliance) were 14,330, as compared to the surgical mask (100% compliance) with 56,200 outpatient visits. However, at 60% compliance, this range narrows to 126,640-128,070. Use of N95 respirators reduces use of hospital beds, ICU beds, and ventilators compared to surgical masks. Estimated hospitalizations for the N95 mask (100% compliance) were 300, as compared to the surgical mask (100% compliance) with 1,190 hospitalizations. However, at 60% compliance, this range narrows to 580-590. N95 respirators and surgical masks had comparable impacts on workdays lost and total economic losses at compliance levels of 60%, but respirators were superior when compliance levels were 100%.	Optimal strategy depends on attack rate and level of compliance wearing masks. Protective efficiency of mask types is based on theoretical calculations involving droplet size, not empiric evidence	2/9
Savoia, 2009[17]	Non-biological counter-measures	US	Exercise, drill, or training program	Pre-post	Infectious disease: Influenza	Tabletop Exercise (and didactic session) to train Public Health officials in what steps they can legally take to limit spread in response to a pandemic	After participating in the course there was a statistically significant increase in most participants' knowledge of and level of confidence in their legal authority to take specific response actions (such as imposing quarantine) to limit pandemic spread.	Legal authority may be present, but procedures to implement that authority may still be lacking... Legal professionals gained somewhat more knowledge	4/7

Appendix E4. D-1. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Schull, 2007[18]	Non-biological counter-measures	Canada/ Australia/ New Zealand	Analysis of single real event	Pre-post with comparison group: Ottawa and London, similar but unaffected regions in Canada	Infectious disease: SARS	Restrict ambulatory and inpatient medical and surgical activity to urgent cases. Respiratory isolation rooms were expanded. Visitor access was severely restricted. A centralized system was created to screen all requests for inter-hospital patient transfers	The rate of overall and medical admissions decreased by 10%–12%; there was no change in the comparison regions. The rate of elective surgery in Toronto fell by 22% and 15% during the early and late restriction periods respectively and by 8% in the comparison regions. Decrease in high acuity ED visits and inter-hospital transfers in Toronto relative to comparison regions suggests potential unintended consequences.	N/A	4/8

Appendix E4. D-2. Strategies to optimize use of existing resources

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Adeniji, 2011[19]	Field triage: Derivation/validation studies	Western Europe	Validation study	Retrospective case review	Infectious disease: Influenza	STSS (Simple Triage Scoring System) to help triage critical care admissions during influenza pandemic	STSS had superior accuracy in predicting ICU need relative to SOFA score - the Area Under the Curve (AUC) of the Receiver Operator Characteristic (ROC) was 0.88 versus 0.77 STSS had superior accuracy in predicting need for mechanical ventilation relative to SOFA score - the Area Under the Curve (AUC) of the Receiver Operator Characteristic (ROC) was 0.91 versus 0.87	Low mortality of H1N1 patients prevented evaluation of predictive accuracy for mortality	3/6
Beyersdorf, 1996[20]	Field triage: Derivation/validation studies	Spokane, WA	Analysis of single real event	Post only with comparison group: Benchmark (implied)	Mass shooting	Preexisting/pre-tested MCE response plan incorporating interagency cooperation, unified communications and incident command, on-scene provider triage, and allocation of casualties based on hospital resources.	A total of 2/19 patients (11%) were over-triaged and 2/19 (11%) were under-triaged. 100% survival.	Pre-hospital vehicles contained job descriptions and duties printed on small cards, and were utilized to establish a command center and chain of command at the scene Designation of a regional disaster control hospital allowed for minute-by-minute knowledge of the capabilities of area hospitals and efficient dispersion of the victims to appropriate facilities. Surgical specialists were preassigned to specific facilities thereby avoiding confusion.	2/6
Cancio, 2008[21]	Field triage: Derivation/validation studies	Iraq	Analysis of multiple real events Validation study	Medical record review	Military/Combat	The use of the Field Triage Score (FTS07) compared to the Revised Trauma Score (RTS) in predicting mortality and massive transfusion.	FTS predicted mortality and massive transfusion nearly as well as the Revised Trauma Score (RTS), but can be calculated without computing assistance in the field.	Often, study patients already had field interventions (such as intubation) performed prior to RTS/FTS assessment	4/6

Appendix E4. D-2. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Casagrande, 2011[22]	Field triage: Derivation/validation studies	Not relevant	Computer simulation	N/A	Nuclear	Use Model of Resource and Time-based Triage to prioritize victims with moderate life-threatening injuries over victims with severe life-threatening injuries, and to prioritize victims with different levels of radiation exposure.	First, when the victim loading is low (i.e., less than or equal to the baseline number of surgical teams and patients),a triage system that prioritizes moderately injured victims followed by severely injured victims followed by mildly injured victims (mod-sev-mild) saves 10% more lives than alternative approaches. Second, as the victim loading increases relative to the resources available (up to 10-fold more patients or 10-fold fewer surgical teams as the baseline), mod-sev-mild saves more than 3-fold more victims than a sev-mod-mild system. Delaying the care of victims with trauma and >0.7 Gy of irradiation increases the number of lives saved by 1.4-fold compared to a system in which irradiated victims are treated exactly like non-exposed victims. The mod-sev-mild triage scheme results in less demand for ICU beds than a sev-mod-mild scheme (15,000 vs. 17,000 on the first day).	N/A	6/9

Appendix E4. D-2. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Guest, 2009[23]	Field triage: Derivation/validation studies	Western Europe	Prospective cohort study prospective data collection during conventional care conditions	N/A	Infectious disease: Influenza	Implement Christian et al.'s triage protocol during an influenza pandemic	For prioritizing ICU admission, sensitivity/specificity for "no significant organ failure" were 0.66/0.83, respectively. For the "palliative treatment only" category, sensitivity and specificity were 0.29 and 0.84, respectively. For prioritizing ongoing ICU care, sensitivity/specificity for "no significant organ failure" were 0.76/0.86, respectively. For the "palliative treatment only" category, sensitivity and specificity were 0.61 and 0.87, respectively.	N/A	5/7
Kilner, 2010[24]	Field triage: Derivation/validation studies	Not relevant	Systematic Review/Meta-analysis	N/A	Explosive, Natural Disaster	Field triage tools for victims of "big bang" incidents (sudden onset MCEs rather than slowly emerging MCEs).	There is limited evidence for the validity of existing triage tools. The authors identify the Sacco triage system as "the most promising" but state that further evaluation of this tool is required.	N/A	8/8
Navin, 2009[25]	Field triage: Derivation/validation studies	Not relevant	Computer simulation	N/A	Unspecified	Use Sacco triage method (vs. START triage) for patients of military age with blunt, penetrating, and blast injuries.	Simulated survivorship improves by 20-300% depending upon the distribution of injuries and resource constraints.	N/A	3/7
Nie, 2010[26]	Field triage: Derivation/validation studies	Asia	Analysis of single real event	Post only with comparison group: Benchmark (START protocol)	Natural Disaster: Earthquake	Use field triage method that accounts for resources at the accepting institution. In this instance, a 'resuscitation' category was added.	The addition of a resuscitation group to standard (START) protocols led to lives saved within that group. 4 of 6 patients in the resuscitation group survived to discharge. These patients would have been classified as 'expectant' under START.	Strategy depends heavily on local decisions. Accuracy of triage may depend on specialty of physician who conducts initial triage.	2/8

Appendix E4. D-2. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Sacco, 2007[27]	Field triage: Derivation/validation studies	Not relevant	Computer simulation	N/A	Any MCE associated with penetrating trauma	Use Sacco Triage Method (as compared to START) for victims with penetrating trauma injuries during an MCE	Under severe resource restrictions, the Sacco Triage Method may save up to an additional 6 to 16 individuals (among 60 simulated victims); whereas the minimum survival benefit is between 0 and 7 victims. When resources are not constrained, the method saves at most 5 additional victims (out of 60).	Method requires inter-hospital coordination with respect to reporting resource availability and receiving patients Method also requires robust communication systems	5/7
Aylwin, 2006[28]	Field triage: Implementation studies *Also in Altered standards	Western Europe	Analysis of single real event	Retrospective case review	Explosive	1) Trained/experienced triage at scene 2) Simplified on-scene triage (urgent (P1 & P2), not urgent (P3), expectant 3) Re-triage at every stage, directed by trained/experienced providers with explicitly designated authority 4) Damage Control approach (minimize use of all critical hospital resources)	Accuracy of on-scene triage was much higher for locations where fully trained responders (versus by medically trained bystanders) performed triage (33% overtriage versus 82% overtriage of critical patients) Speed of scene clearance - Average of 27 P1 & P2 (most seriously wounded) patients per hour (= 2.2 minutes per patient) Second stage screening (at the ED Door) reduced the surge demand (by screening out over-triage and identifying under-triaged/deteriorating patients) reducing initial overtriage to 0% and undertriage to 20% of critical patients. Increase available surge capacity - created 10 ICU bed spaces and made all ORs available within 2 hours	N/A	5/8

Appendix E4. D-2. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Cohen, 1998[29]	Field triage: Implementation studies	Israel	Analysis of multiple real events	Retrospective case review	Explosive	Use American College of Surgeons Committee on Trauma criteria during field triage for blast MCE injuries.	Field undertriage rate - 0/26 (0%) critical patients, 4/28 (14%) severely injured, and 19/143 (13%) moderately injured patients initially classified as less severe Field overtriage rate - 12/36 (33%) minor injury patients initially classified as more severe	Experience of field triage providers	4/8
Cone, 2009[30]	Field triage: Implementation studies	US	Exercise, drill, or training program	Post only with comparison group: Benchmark	All-hazards	Use of the Sort- Assess-Lifesaving Interventions-Treatment/transport (SALT) triage protocol.	Study participants (paramedics) using SALT had a 78.8% accuracy rate. The overtriage rate was 13.5% and the undertriage rate was 3.8%. The undertriage rate is lower than the 5% the authors assert is standard in the literature. Average triage time was 15 seconds (median: 11.5 seconds; range 5-57 seconds).	Time elapsed between training on triage method and application of methodology. Training level and experience of triage provider (EMT, Paramedic, MD, etc.) may also influence accuracy	5/8
Cone, 2008[31]	Field triage: Implementation studies	New Haven, CT	Exercise, drill, or training program	Post only with comparison group: Gold standard triage category	Chemical	Use combined trauma/CBRN-specific triage method during an MCE.	Overtriage rate (1.8%, 1/56 patients) Undertriage rate (10.8%, 6/56 patients) Triage speed - 19 seconds per patient	Inaccuracy in triage mostly due to missing signs of chemical toxidrome	6/8

Appendix E4. D-2. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Cryer, 2010[32]	Field triage: Implementation studies	Los Angeles County, CA	Analysis of multiple real events	Pre-post	Transportation accident	1) Use a trauma system performance improvement program to evaluate MCE response, identify shortcomings, and change policy based upon the findings. 2) Use air transport to facilitate distribution of "immediate" patients evenly to area trauma centers. 3) Encourage EMS to distribute all victims meeting "trauma center criteria" to trauma centers rather than to non-trauma community hospitals.	Regional EMS quality improvement plan can improve the distribution of patients to appropriately resourced hospitals in mass casualty events. In the 2005 train crash only 44% (11/25) of "immediate" patients were taken to trauma centers, as compared to 89% (55/62) in 2008. In the 2005 crash, only 2 patients were transported by air; in 2008, 34 were transported by air.	N/A	5/8
Gutsch, 2006[33]	Field triage: Implementation studies	Western Europe	Exercise, drill, or training program	Post only with comparison group: Benchmark	Unspecified	Use mSTART triage algorithm	Triage time by EMTs was a median of 35 seconds each (average 41 seconds), which compares favorably with emergency physician average of ~3 minutes. EMT critical red over-triage was 5.3% and critical red under-triage was 3% (both are considered excellent). Sensitivity was 88%, and specificity was 94%.	N/A	4/4
Janousek, 1999[34]	Field triage: Implementation studies	US	Exercise, drill, or training program	Post only with comparison group: Provider groups compared against each other.	Chemical, Biological, Nuclear, Trauma: War	The use of various providers types in doing MCE triage.	Physicians had higher triage accuracy scores than other military healthcare providers (nurses, dentists and medics, using the NATO triage classification system (mean score of 54, compared to 50--denominator could not be determined). There were no statistically significant differences between emergency physicians, surgeons and general medical officers. Likewise, there were no differences between medics, nurses and dentists.	N/A	3/7

Appendix E4. D-2. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Kuniak, 2008[35]	Field triage: Implementation studies	US	Exercise, drill, or training program	Post only with comparison group: Gold standard disposition categories	Radiological	Use Radiation Injury Severity Classification (RISC) for early triage of radiation MCE casualties when dosimetry data are unavailable	Accuracy of raters' classification was approximately 95%.	Trend towards training level affecting triage accuracy (MD>RN>EMT) Hematologic component proved most difficult to score System allows for the rapid assessment of ARS severity without the availability of dose information Less complex than other systems (e.g., METROPOL) and is amenable to self-education.	6/8
Lerner, 2010[36]	Field triage: Implementation studies	Augusta, GA & Milwaukee, WI	Exercise, drill, or training program	Post only with comparison group: Benchmark (START protocol)	Explosive	Use of the Sort- Assess-Lifesaving Interventions-Treatment/transport (SALT) triage protocol	Performance using the SALT protocol was comparable to other studies using the START triage protocol. Final triage was correct 83% of the time (CI: 78-88%), compared to START studies (48-75%). 6% were overtriaged and 10% were undertriaged. Timing using the SALT protocol was comparable to other studies using the START triage protocol. Mean triage time was 28 seconds (Std dev: 22 sec), compared to 30 seconds for START. Further, this study used simulated 'patient' interference, which may have increased triage times.	N/A	5/8

Appendix E4. D-2. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Rehn, 2010[37]	Field triage: Implementation studies	Western Europe	Exercise, drill, or training program	Pre-post	Transportation accident	TAS Triage Method for bus crash type MCE (combines triage Sieve for adults and trauma tape for pediatric patients)	Overtriage rate before implementation of TAS: 9/74 (12.2%), versus 0/74 (0%) after implementation of TAS Undertriage rate before implementation of TAS: 9/24 (12.2%) , versus 0/24 (0%0 after implementation of TAS Scene clearance rate - mean: 22 minutes (range 15-32) before implementation of TAS, versus mean: 10 minutes (range 5-21) after implementation of TAS	Need TAS Training Need TAS Equipment Probably easier to collect accurate input data under simulation conditions than in real MCE	6/8
Rodriguez-Noriega, 2010[38]	Field triage: Implementation studies	Mexico	Analysis of single real event	Prospective case series	Infectious disease: Influenza	Use Influenza-Like Illness Scoring System to triage adults seeking care at an ED during an influenza pandemic. Patients with high scores are admitted and treated with oseltamivir. Those with intermediate scores are sent home with oseltamivir and followed up by phone daily for 10 days. Those with low scores are discharged home without treatment.	Of 1324 ambulatory patients who were discharged without receiving oseltamivir, 14 (0.8%) returned after their initial visit. Three of these patients were hospitalized and treated with oseltamivir (two of them tested positive for H1N1).	N/A	5/8
Schenker, 2006[39]	Field triage: Implementation studies	New York, NY	Exercise, drill, or training program	Post only with comparison group: Benchmark	Chemical, Explosive, Transportation accident	Implement START triage algorithm during mass casualty event	A total of 88/121 patients (70%) were triaged accurately. A total of 29 of 47 patients (62%) were managed appropriately when their clinical status was altered as part of the exercise. Six patients who underwent status changes indicating a possible myocardial infarction or asthma attack were classified as over-triaged according to START but were judged to be managed appropriately by exercise staff.	N/A	6/8

Appendix E4. D-2. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Zoraster, 2007[40]	Field triage: Implementation studies	Los Angeles, CA	Analysis of single real event	Retrospective case review	Transportation accident	Use of START triage by a regional trauma network to prioritize transport of MCE patients and to distribute them among area hospitals.	Trauma centers were underutilized and community hospitals received critical patients that they were poorly equipped to handle.	Hospital capacity self-report was inaccurate START categorization scheme was imperfectly understood START triage categories differ from trauma center criteria, causing confusion	4/6
Gao, 2007[41]	Field triage: Other	US	Exercise, drill, or training program	Post only with comparison group: Paper triage tags	Unspecified	Use electronic triage tags (Advanced Health and Disaster Aid Network, AID-N) to monitor vital signs and transmit information to first responders.	Time required for triage was similar in both electronic and paper triage groups. Electronic triage tags allowed first responders to re-triage patients three times more often as first responders who used paper triage tags.	Triage status indicator used LEDs that were difficult to see from a distance under bright sunlight and when the triage tag was flipped over on the patient. Patients might wander out of range or vehicles (e.g., fire trucks) might block data transmissions. Pulse oximeter readings have limited accuracy in the presence of methemoglobin, carboxyhemoglobin, nail polish, nail fungus, fluorescent light, and motion. Tags used at least eight times less energy than existing, similar devices	5/8
Hirshberg, 2010[42]	Field triage: Other	Not relevant	Computer simulation	N/A	Explosive	1) Use a 2-stage triage system for large-scale MCEs 2) Use most experienced physician for the first step of triage	Single-step triage works well for small-scale incidents. When resources are overwhelmed, 2-stage triage substantially increases the "time to saturation" (point at which ED is at full capacity). If two triage providers have 70% and 90% accuracy, assigning the better provider to the first step of a sequential triage increases time to saturation by approximately 50%.	Value of 2-step procedure varies with the ratio of casualties to provider teams Model does not deal well with the possibility of under-triage in two-step process	6/9

Appendix E4. D-2. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Romm, 2011[43]	Field triage: Other	US, Canada/ Australia/ New Zealand, Western Europe, Asia	Laboratory test	N/A	Radiological, Nuclear	Use fewer metaphase spreads when using the dicentric chromosome assay method of biodosimetry for mass radiological incidents.	Analyzing 50 metaphases gives reliable and accurate individual dose estimations over the dose range of 0.75 to 4.5 Gy. Most of these dose estimations are within 20% of the actual doses. Dose estimations based on analysis of only 20–30 metaphases allowed an accurate evaluation in the higher dose ranges. (Routine standard is 500-1000 metaphases)	Range of exposure doses and uniformity of exposure will impact effectiveness of strategy.	5/5
Epley, 2006[44]	Load sharing	Southwest Texas	Analysis of multiple real events	Pre-post with comparison group: Routine trauma system (pre-/post-) and disaster trauma system	All-hazards, Natural Disaster: Hurricane	Use of comparable coordinated regional trauma systems for routine (Medcom) and disaster (Regional Medical Operations Center) operations to facilitate the rapid transfer of hospitalized and special needs patients following small-scale trauma events and disasters.	Pre-post- analysis of Medcom: • Pre-Medcom (10 mos.): Transfer decision time 115 +/-3 min; transfer accept time 30.5min; total transfer time 145+/-12min. • Post-Medcom (10 yrs): Transfer decision time 80+/-1min, transfer accept time 10 +/- 2 min, total transfer time 91 +/- 1 min Regional Medical Operations Center (RMOC) : • Post-Hurricane Katrina- transferred 6 patients/hour & 170 patients/hour from 2 incoming transports • Pre-Hurricane Rita: transferred 20 patients/hour	Medcom (routine) and RMOC (disaster) regional trauma systems are comparable, inter-related and symbiotic. Medcom is practical small-scale rehearsal for major disasters. Authors unaware of comparative data between trauma system; benchmarks would be useful.	4/8

Appendix E4. D-2. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Simon, 2001[45]	Load sharing	NYC	Analysis of single real event	Post only with comparison group: Qualitatively compared against counterfactual	Explosive, Terrorism	1) Control the distribution of urgent patients through scene or central command to limit overwhelming the nearest hospital. 2) Site emergency management centers in a low vulnerability location. 3) Use robust and interoperable emergency communications systems.	No enforced patient distribution system led to moderate and critical patients swamping the two nearest trauma centers, while a 3rd trauma center 3 miles from scene sat idle Attack damage to Office of Emergency Management (OEM) dramatically exacerbated communication and coordination efforts including patient distribution Cell phone and radio disruptions (from attack damage and post-attack overload) prevented response coordination - most patient distribution was blind to hospital resource availability	N/A	2/8

Appendix E4. D-2. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Kanter, 2007[46]	Load sharing *Also in Altered standards	Not relevant	Computer simulation	N/A	Unspecified	1) Control distribution of pediatric disaster victims to avoid overcrowding near scene 2) Expand hospital capacity by altering standards of care to provide only "essential interventions"	Simulated mortality was reduced both by controlling the distribution of disaster victims and by relaxing standards of care. The greatest reduction was achieved by employing both strategies together.	Findings are based upon a variety of untested and extrapolated assumptions. Thus, "the reported results are not intended to recommend particular response strategies." A large urban center is modeled; the applicability to rural or suburban environments is unclear.	3/9
Leiba, 2006[47]	Load sharing	Israel	Analysis of single real event	Post only with comparison group: Benchmark (implied)	Explosive	1) Central allocation of patients to hospitals based on available resources 2) Central information system and local hospital information offices remote from care areas 3) Simplified field triage system - urgent (P1 & P2), non-urgent (P3), and expectant (P4) to speed scene clearance	Avoidance of individual hospital overload - 5/13, 5/13 and 3/13 urgent patients triaged to three nearest Level I trauma centers Limited diversion of medical care personnel to family/media information needs Speed of scene clearance - all 21 urgent (and 2 DOA) casualties evacuated in 25 minutes. All ambulance patients cleared within 35 minutes	N/A	2/8
Raiter, 2008[48]	Load sharing	Israel	Analysis of single real event	Post only with comparison group: Benchmark (implied)	Explosive	1) Central Incident Command System (ICS) which gathers data and assigns patients to receiving hospitals 2) Robust redundant communications channels between Command Center, Responders, and Receiving Hospitals	Optimal allocation of resources (patients to hospitals) - no overload of capacity - nearest Level I got 5/9 severe patients, Level II got 4/9, 59 mildly injured patients distributed amongst 5 hospitals Effective communication between responding entities - cell phone service overloaded/failed, radio, beeper & internet channels functioned smoothly	N/A	3/8

Appendix E4. D-2. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Wolf, 2009[49]	Load sharing	Western Europe	Exercise, drill, or training program	Post only with comparison group: Benchmark	Unspecified	New model to accommodate MCEs with >200 casualties, including on-site triage and stabilization and immediate transport of severely injured patients to modular "Initial Care Hospitals" for further stabilization and emergency treatment including surgery	Mean time from registration to entry into operating room for 10 patients needing emergency surgery was 19.5 minutes National standard was met at the designated "Initial Care Clinic": 60-minute lead time (from alert to full preparedness and maximum influx of patients)	N/A	8/8
Xiong, 2010[50]	Load sharing	Not relevant	Computer simulation	N/A	Natural Disaster: Earthquake	Implement regional telemedicine hub to support delivery of specialty care during MCE	Use of the telemedicine hub reduced the number of deaths by 5.4%, 36.5% and 27.3% for the major, medium and minor scale earthquake scenarios respectively. Use of the telemedicine hub reduced local ED bed usage and local trauma specialist usage for medium and minor earthquakes. Use of the telemedicine hub lowered average wait times for ED beds and specialists.	Rapid availability of specialists external to the event are required Local ED resources may serve as a bottleneck and require higher rates of transfer even when the telemedicine hub is operational	2/7
Beck-Razi, 2007[51]	Imaging	Israel	Analysis of single real event	Medical record review	Explosive, Trauma: War	Use of focused assessment of sonography for trauma (FAST) in for MCE triage.	FAST results were generally consistent with the results of CT scans, laparotomy and clinical observation. Overall accuracy of FAST (compared to other methods) was 93.1% (sensitivity: 75.0%, specificity: 97.6%).	Sonography in this study was performed and interpreted by radiologists, not emergency medicine physicians/providers Type of injury varied between soldiers (open wounds and fractures) versus civilians (blast/shrapnel injuries) FAST only can detect fluid/air so can diagnose bleeding, but cannot exclude all clinically important types of abdominal injury	6/8

Appendix E4. D-2. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Korner, 2006[52]	Imaging	Western Europe	Exercise, drill, or training program	Pre-post with comparison group: Individually admitted patients after multiple trauma (historical)	Unspecified	Implement accelerated whole body multislice computed tomography protocol (Triage MSCT)	Use of the triage MSCT protocol allowed a throughput of 6.7 patients per hour compared to 2.4 patients per hour for the standard protocol. Triage MSCT protocol produced an average of 201 images per patient compared with 1031 images per patient for the standard protocol.	Triage MSCT patients were assumed to undergo preparation at the site of the MCE or during transport, did not undergo focused abdominal ultrasound, and were transferred directly to the CT exam room. This accounted for most of the throughput gain. To decrease image number and image calculation time, no high-resolution reformations and multiplanar reformations were calculated in the Triage MSCT group. Tube cooling problem were encountered when using the Triage MSCT protocol that required a reduction in dose for each scan and consequently the potential for lower image quality. This issue may be avoided by using newer scanners. Staff participating in the study were instructed before the simulation on how to operate the CT console with the new MSCT protocol.	5/7
Korner, 2011[53]	Imaging	Western Europe	Exercise, drill, or training program	Post only with comparison group: 4-slice MDCT	MCEs involving major trauma	Use 64-slice multi-detector computerized tomography scan (vs. 4-slice MDCT) with high volume image reading capabilities to facilitate triage during MCEs	The 64-MDCT protocol reduced image processing time from an average of 9.0 minutes to 4.1 minutes.	Large volume of data led to an overload of the 3D workstation; backups workstations would be required Image quality might be a modulator but it was not assessed as part of the study	7/8

Appendix E4. D-2. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Sarkisian, 1991[54]	Imaging	Eastern Europe	Analysis of single real event	Retrospective case review	Natural Disaster: Earthquake	Sonographic screening for abdominal/pelvic injury or bleeding to triage earthquake MCE casualties and screen for occult injuries	False positive rate of 0/345 (0%) among patients without true abdominal trauma. (Reviewers' calculation) False negative rate of 4/55 (7.2%) among patients with true abdominal trauma. (Reviewers' calculation) Mean exam time of 4 minutes (Range: 1-10 minutes)	N/A	4/8
Gunal, 2004[55]	Medical interventions	Asia	Analysis of single real event	Post only with comparison group: Benchmark (historical comparison)	Natural Disaster: Earthquake	An organized, on-site medical intervention for the prevention of acute renal failure in crush victims after a catastrophic earthquake.	Only 4 of 16 patients with rhabdomyolysis required hemodialysis. All 16 survived. This is compared to dialysis rates of 60.8% and 77% for comparable patients in two recent earthquakes, and to other reported mortality rates of 15%-40% for patients who require hemodialysis.	N/A	6/8
Vardi, 2004[56]	Medical interventions	Israel	Exercise, drill, or training program	Randomized controlled trial	Chemical	Spring-driven intraosseous infusion device to replace IV insertion in a chemical MCE where providers are in full protective gear.	Simulated survival with/without IO device use - 73.4% survival versus 3.3% survival (under the simulation rules) Total average casualty treatment time with/without device - 207 seconds versus 590 seconds	Anesthesiologists performed faster in both treatment and control groups	6/8
Satterthwaite, 2010[57]	Space optimization	Australia	Analysis of single real event	Retrospective case review	Explosive, Transportation accident	Use reverse triage to create surge capacity, including: suspension of normal elective activity, discharging patients earlier in the day, and increasing use of community care options such as respite nursing home beds and community nursing services)	Nineteen patients were discharged early (and would not have been discharged early under normal conditions). Seven patients were ultimately readmitted, however, early discharge did not increase clinical risk.	N/A	2/7

Appendix E4. D-2. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Scarfone, 2011[58]	Space optimization	Philadel-phia, PA	Analysis of single real event	Pre-post	Infectious disease: Influenza	1) Appropriate space for other uses, including: 1) converting the hospital lobby to an ED waiting room 2) using a subspecialty clinic to care for non-urgent patients, and 3) using a 24-hour short stay unit to care for ED patients. 2) Use physicians not board certified in pediatric emergency medicine and inpatient-unit medical nurses to care for ED patients. 3) Other strategies included stockpiling PPE, antiviral medication, and bed surfaces, and the use of a tiered distribution of H1N1 vaccine.	Both patients' average wait time in the ED and the rate of leaving the ED without being seen during the pandemic were less than rates measured during the peak of seasonal influenza in the prior year. The ED continued to accept all children brought by local ambulance crews, and never went on divert status.	Decision to abandon initial plan to treat all children with ILI in one or more unit	2/8
Van Cleve, 2011[59]	Space optimization	Seattle, Washington	Analysis of single real event	Pre-post	Infectiou`s disease	Reverse triage to identify patients for release and increase inpatient surge capacity	The hospital discharged essentially the same number of patients on November 4 as on previous high-census days when the surge plan was not activated, suggesting that the surge plan did not succeed in creating excess discharges.	The hospital never declared a disaster abd never sytematically implmented reverse triage	5/8
Andreatta, 2010[60]	Training	Ann Arbor, MI	Exercise, drill, or training program	Randomized controlled trial	Explosive	Use virtual reality to teach START triage	Virtual reality-based triage performance did not lead to improved performance compared to (traditional) standardized patient triage training.	Higher up-front costs for VR development	6/6

Appendix E4. D-2. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Hsu, 2004[61]	Training	US, Western Europe, Eastern Europe, Asia	Systematic Review/Meta-analysis	N/A	All-hazards, Chemical, Biological, Radiological, Nuclear, Explosive, Transportation accident	1) Conduct hospital disaster drills to train hospital staff to respond to a mass casualty event 2) Use computer simulations to train hospital staff to respond to a mass casualty event 3) Conduct tabletop or other exercises to train hospital staff to respond to a mass casualty event	Disaster drills have the potential to identify problems with incident command, communications, triage, patient flow, materials and resources, security, and decontamination. Disaster drills usually were not designed to evaluate the effectiveness of patient care. Computer simulation was able to identify bottlenecks in patient care, electromechanical failures, crowd control issues and other security problems, and resource deficiencies. Evidence is insufficient to reach definitive conclusions regarding the effectiveness of computer simulations or tabletop exercises.	N/A	7/10
Jarvis, 2009[62]	Training	Western Europe	Exercise, drill, or training program	Randomized controlled trial	Unspecified	Use computer game method of triage training	Computer game participants achieved higher triage tagging accuracy (compared to participants in a tabletop exercise)	Providing interim feedback improves step accuracy but not accuracy of triage classification.	4/8
Sanddal, 2004[63]	Training	US	Exercise, drill, or training program	Pre-post	Explosive, Transportation accident	A 1 hour training program to improve pediatric triage performance ("JumpSTART")	The training session improved triage performance and that improvement was sustained at 3 months.	Motivation and abilities of trainees The generalizability of performance improvement to other scenarios (or to any non-drill situation) is unknown. The sustainability of performance improvement beyond 3 months is unknown. Using triage tags rather than simulating them was found to be helpful	6/8

Appendix E4. D-2. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Vincent, 2009[64]	Training	US	Exercise, drill, or training program	Pre-post	Explosive	Teach triage skills using podcasts and iterative multi-manikin simulations	Accuracy of triage, choice of intervention, and rapidity of triage all improved with training.	Performance may vary with mechanism of injury Improvement might have resulted from technical familiarity with manikins rather than improvement in triage skills.	3/5
Vincent, 2008[65]	Training	US	Exercise, drill, or training program	Pre-post	Unspecified	Teach mass casualty triage skills using an immersive 3D Virtual Reality environment.	Triage accuracy and intervention scores improved significantly after one iteration of training. Time to complete the scenario improved with each iteration.	There may have been a selection bias, with more technologically savvy learners signing up to participate in this trial Apparent performance gains could reflect familiarity with VR equipment rather than improved triage knowledge	4/7
Amlot, 2010[66]	Other	Western Europe	Exercise, drill, or training program	Randomized controlled trial	Chemical, Biological, Radiological, Nuclear	Use of instructions, washcloth and/or shower duration to increase decontamination effectiveness	Any form of showering is more effective than not showering; however, the use of a washcloth significantly improved results over showering alone, showering with instructions or showering for longer. Washcloth use led to 20% less contamination, compared to other interventions.	Showering instructions were provided before the shower, and were not available during the shower, which may have reduced effectiveness.	3/6

Appendix E4. D-2. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Einav, 2009[67]	Other	Israel	Analysis of multiple real events	Pre-post	Explosive	Use of case managers in supervising patient care and transfer of care throughout an MCE.	Using case managers improved patient management and flow with similar staff and no additional resources. Reductions were observed in: the number of x-rays/patient/1st 24-hour (P < 0.001), time to performance of first chest x-ray (P = 0.015), time from first chest x-ray to arrival at the next diagnostic/treatment location (P = 0.016), time from ED arrival to surgery (P = 0.022) and hospital lengths of stay for critically injured casualties (37.1 +/- 24.7 versus 12 +/- 4.4 days, P = 0.016 for ISS > or = 25). Using case managers had no adverse impact on the health outcomes of critically injured patients. Mortality rates were similar for critically injured patients.	N/A	3/8
Loeb, 2009[68]	Other	Canada	Analysis of single real event	Randomized controlled trial	Infectious disease: Influenza	The use of surgical masks in place of N95 respirators to protect healthcare workers against influenza.	Surgical masks were deemed noninferior to N95 respirators. The lower end of the 95% confidence interval for the reduction in incidence of influenza (N95-surgical) was greater than the established noninferiority limit of -9%.	N/A	5/6

Appendix E4. D-3. Strategies to augment existing resources

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Blackwell, 2007[69]	Temporary facilities	US	Analysis of single real event	Post only with comparison group: Qualitatively compared to implied standard of limited or no care available.	Natural Disaster: Hurricane	Deploy a mobile field hospital	7,400 patients were evaluated and treated over a 6-week period.	N/A	3/5
Eastman, 2007[70]	Temporary facilities	Dallas, TX	Analysis of single real event	Pre-post	Natural Disaster: Hurricane	Implement alternate-site surge capacity facility during a mass casualty event	All other trauma centers/EDs in Dallas had no statistically significant increases in visit rates during the two-week period in which the alternate care site was operational compared to visit rates in the prior year. There were no incidents of safety or contamination breaches during operation of the alternate care site.	Leadership team for the alternate care site also served as medical direction team for the City of Dallas Emergency Medical Services and enhanced effectiveness through greater coordination with other agencies. Availability of space and physical structure (especially climate-controlled) Level I centers were required to provide staff and resources, and took nearly 7 days to obtain necessary equipment. Limited capabilities for surgical intervention.	4/7
Wein, 2003[7]	Temporary facilities *Also in Reduce demand	Not relevant	Computer simulation	N/A	Infectious disease: Anthrax	1) Aggressive and rapid antibiotic distribution post Anthrax mass attack detection 2) Dramatically expanded POD & hospital surge capacity (for example by cross training, and using non-hospital volunteers to extend trained personnel, and mobile servers from other federal agencies to provide hospital surge capacity)	The Number of Deaths (relative to base case strategy of no or very delayed treatment) is a function of the speed of distribution - Mass antibiotic distribution reduces deaths to 123,000 (8.3% of base case) versus 660,000 deaths (44% of base case) if only symptomatic patients are treated Number of Deaths (relative to base case strategy) - function of hospital capacity - dramatically decreased with sufficient personnel - ten-fold or more, and mobile servers (e.g., from other federal agencies)	Antibiotic Efficacy Adherence to prophylactic regimen Adding mobile servers (to provide surge hospital care) is more effective than adding local servers because the former are typically less busy and therefore more available.	5/9

Appendix E4. D-3. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Arora, 2010[1]	Other *Also in Reduce demand	Not relevant	Computer simulation	N/A	Infectious disease: Influenza	1) Determine what proportion of CDC stockpile to preallocate in response to pandemic flu outbreak. 2) Implement mutual aid agreements that allow transshipment of antivirals between counties. 3) Allocate CDC stockpile according to age group, gross attack rate, or population only. 4) Determine what proportion of CDC stockpile to use for prophylaxis vs. treatment for pandemic flu outbreak.	Postponing allocation is optimal by allowing allocation according to the infected population rather than the susceptible population. Transshipment through mutual aid agreements is an optimal policy when infection rates vary across counties and counties with small populations are affected. Allocate CDC antiviral stockpile according to gross attack rates rather than population is the optimal strategy. Age-based allocation may also be optimal. Limit use of CDC antiviral stockpile for prophylaxis when supplies are limited and focus on treatment instead.	Vaccine effectiveness is lower among the elderly	4/7
Corvino, 2006[71]	Other	US	Laboratory experiment	N/A	Chemical	Convert Pralidoxime (2-PAM) in autoinjectors into IV form if needed to respond to nerve agent MCE	Resulting formulation is potent and stable - Greater than 90% potency at 28 day post-preparation, with no bacterial contamination or detected physical changes	N/A	6/7

Appendix E4. D-3. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Aylwin, 2006[28]	Damage-control surgery/care *Also in Optimize resources	Western Europe	Analysis of single real event	Retrospective case review	Explosive	1) Trained/experienced triage at scene 2) Simplified on-scene triage (urgent (P1 & P2), not urgent (P3), expectant 3) Re-triage at every stage, directed by trained/experienced providers with explicitly designated authority 4) Damage Control approach (minimize use of all critical hospital resources)	Accuracy of on-scene triage was much higher for locations where fully trained responders (versus by medically trained bystanders) performed triage (33% overtriage versus 82% overtriage of critical patients) Speed of scene clearance - Average of 27 P1 & P2 (most seriously wounded) patients per hour (= 2.2 minutes per patient) Second stage screening (at the ED Door) reduced the surge demand (by screening out over-triage and identifying under-triaged/deteriorating patients) reducing initial overtriage to 0% and undertriage to 20% of critical patients. Increase available surge capacity - created 10 ICU bed spaces and made all ORs available within 2 hours	N/A	5/8

Appendix E4. D-3. Continued.

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Dhar, 2008[72]	Damage-control surgery/care	Asia	Analysis of single real event	Post only with comparison group: Comprehensive care (implied)	Natural Disaster: Earthquake	"Damage control" surgery for the orthopedic injuries of MCE polytrauma patients if referral to hospital is delayed or comprehensive care resources unavailable	Acceptable outcome at 1 year compared with comprehensive care = 49/62 (79%) "excellent" or "good" outcomes; only 3 non-unions (unhealed fractures) Mortality - 0% Operating Room Time (relative to definitive repair) - mean: 38.5 minutes for external fixation (37% of internal fixation time)	Results inferior for intra-articular (joint involved) fractures	5/8
Labeeu, 1996[73]	Damage-control surgery/care	Rwanda	Analysis of single real event	Post only with comparison group: Standard care (implied)	Trauma: War	External fixation of fractures rather than definitive orthopedic care	External fixation used for 1,129 fractures. Average time of placement was 30 minutes. Numerous complications, not quantified. Authors consider this to be the best compromise between nonoperative methods and definitive care.	N/A	1/6
Kanter, 2007[46]	Other *Also in Optimize resources	Not relevant	Computer simulation	N/A	Unspecified	1) Control distribution of pediatric disaster victims to avoid overcrowding near scene 2) Expand hospital capacity by altering standards of care to provide only "essential interventions"	Simulated mortality was reduced both by controlling the distribution of disaster victims and by relaxing standards of care. The greatest reduction was achieved by employing both strategies together.	Findings are based upon a variety of untested and extrapolated assumptions. Thus, "the reported results are not intended to recommend particular response strategies." A large urban center is modeled; the applicability to rural or suburban environments is unclear.	3/9
Merin, 2010[74]	Other	Haiti	Analysis of single real event	Post only with comparison group: Standard care (implied)	Natural Disaster: Earthquake	Altered standards of care, and allocation of resources towards patients most likely to benefit.	Authors assert that they treated more patients than they would have if they had not relaxed standards of care or had they not allocated resources with the goal of maximizing the number of lives saved.	N/A	1/6

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